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ABSTRACT

Information sheets and student worksheets for twenty-five lesson plans designed for a third-year electrical apprentice technical training program are presented in this workbook. The information sheets provide summary information about the lesson topics and the worksheets contain problems to be solved and questions to be answered relating to each lesson. Some of the lesson topics are alternating currents, power factors, correction, class III installations, gasoline dispensing and service stations, fundamentals of motor control, and estimating job costs. (The instructor's manual containing lesson plans, unit tests, and worksheet answers is available as CE 018 357. Other related documents are CE 018 350-360.) (JH)

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ED 160 883

STUDENT WORKSHEETS

RELATED INSTRUCTIONAL MATERIAL

FOR

ELECTRICAL APPRENTICE

TECHNICAL TRAINING

SERIES C

(Third Year)

Revised to meet 1978 Electrical Code

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND THE ERIC SYSTEM CONTRACTORS."

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

CE 018 358

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FOREWORD

The apprenticeship programs offered in North Carolina are important phases of the total educational program for industry in the state. The program of education for modern apprenticeship includes two distinct phases. The first phase is "on-the-job training." The student is employed by a firm in which duties are specifically assigned to enhance ones learning in the field of study. These experiences are planned and supervised so that the individuals will progress through the apprenticeship phase to that of the journeyman. The second phase of the program of education is termed "related instruction." In this phase the apprentice is provided the technical and theoretical foundation subjects that help one to learn the trade thoroughly and accurately. This portion is usually taught through evening school, but in some cases may be done through correspondence courses.

The North Carolina Department of Community Colleges, through the Program Development Section, has the responsibility for developing and making available the instructional materials that provide the learner with a sound educational program which is effective and appropriate to the method in which the materials are being utilized. The department has available these materials for the students, as well as support material for the instructor who teaches or who acts as counselor in conducting the related classes.

Roger G. Worthington

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PREFACE

The Program Development Section of the Department of Community Colleges has the responsibility for making available the related instructional materials required for use in occupational programs offered by the various institutions. This responsibility is accomplished by working with advisory committees and consultants representing each of the occupations in determining the needs and in developing the materials required to meet these needs.

These information sheets and worksheets have been prepared to provide specific assignments for studying related topics necessary in the training of electrical apprentices. An effort was made to develop the schedule to follow as the apprentice progresses with training. It will also enable the apprentice to know what skills and knowledges will be required. The objective of this program is to aid the instructor and employer in providing experiences necessary to develop not only a competent worker in the electrical field, but also, a well-rounded citizen.

This workbook includes assignment sheets and information sheets for the electrical apprentice to use in searching out related information. The worksheets contain problems to solve, questions to answer diagrams to draw, and blueprints to consult. The apprentice should study the references (assigned by the instructor) before attempting to answer the questions or solve the problems.

In actual use of these lessons, instructors should feel free to modify their application of the material to conform with local needs. For example, there may be certain sections of the Code to teach because the apprentices are working with special installations. Thus, the instructor should lead a discussion on materials that applies to these situations. In other classes, the instructor may need to spend more time with the students on topics dealing with mathematics than with blueprint reading. In any event, the minimum class time for related material is 144 hours per year. It is sincerely hoped that the assignment sheets are used correctly so that apprentices can gain maximum benefits from their related studies.

ELECTRICAL APPRENTICESHIP TECHNICAL TRAINING

ACKNOWLEDGMENTS

Questions and problems for the Lesson Topics were prepared in July, 1964 by:

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NAME _____ LESSON C-1

DATE _____ WORKSHEET

ALTERNATING CURRENT

1. Alternating current or voltage is one which is reversed at _____ intervals.

2. A cycle or "Hertz" is a complete set of _____ through which an alternating current passes.

3. One cycle or "Hertz" is equal to _____ electrical degrees. (180°, 270°, 360°).

4. The expression "60 cycles or Hertz per second" means that the current referred to makes _____ complete cycles in a second. (60, 120, or 30)

5. Most electric power companies generate, transmit, and distribute their power at _____ cycle frequency

6. If 25 cycles are used for lighting, there will be _____ of the lamps.

7. "Phase" is a term used to express time. True/False _____

8. Three-phase current is three different alternating currents 120° out of phase. True/False _____

9. Name three circuit characteristics that may affect the value of the current in an A. C. circuit. _____, _____,& _____

10. Effective values of _____ _____ and voltage are the ones ordinarily referred to when speaking of alternating quantities.

11. The maximum value of alternating current or voltage is _____ _____ _____.

12. The average value of alternating current or voltage is _____ _____ and _____ times _____ _____.

13. The _____ value of alternating current or voltage is _____ times _____ _____.

14. Effective power is equal to product of _____ voltage and _____ current.

15. Magnetic field expanding and contracting with a _____ _____ produces inductance.

16. Inductance produces _____ to flow of current and makes the current _____ the _____.

NAME _____ LESSON C-2

DATE _____ WORKSHEET

RESISTANCE IN A. C. CIRCUITS

1. List two factors which may cause an increase in resistance in A. C. circuits:

   (a) _____ (b) _____

2. Pure resistance circuits consist of electrical devices containing no _____ or _____.

3. _____ values of A. C. voltage and current must be used in circuit laws and rules.

4. For practical use, all A. C. voltage and current values are given as _____ values.

5. In a resistive circuit, Ohm's Law and Kirchhoff's Laws can be used as is in an _____ circuit.

6. _____ and _____ are in phase in resistive circuits.

7. What is meant by the term "in phase"? _____

   _____

   _____

8. The value of voltage in A. C. circuits at _____°, _____°, and _____° is 0.

9. _____ power is the actual power used in an A. C. circuit.

10. Average power is exactly one-half of _____ instantaneous _____.

11. Power is equal to the product of _____ and _____.

12. Power is expressed in terms of _____ or _____ _____.

13. Resistance is expressed in terms of _____.

14. Power factor is expressed in _____ or _____.

15. Power factor in a resistive circuit has a value of _____.

16. Power factor is the ratios of _____ of the circuit and _____ _ _____ of the circuit.

17. Find the power and the power factor of a resistive circuit with impressed voltage of 220 volts and current of 10 amperes.

18. A water heater rated 5000 watts is connected on a 220 volt system. Find the current in the A. C. circuit.

NAME _____ LESSON C-3

DATE _____ WORKSHEET

INDUCTANCE AND INDUCTIVE REACTANCE

1. Inductance exists because an electric current produces a _____ _____.

2. The strength of the _____ _____ is dependent on the change of current.

3. Small current flow produces a _____ magnetic field.

4. Large _____ _____ is produced by a _____ current flow.

5. Magnetic field expands and contracts with varying current causing an EMF of varying _____ and the effect known as _____.

6. No current flow produces no _____ _____.

7. Inductance is produced only with a _____ IN CURRENT.

8. In a D. C. circuit, a constant current produces _____ inductance.

9. In a D. C. circuit, inductance is produced only when the power is _____ _____ or _____ _____.

10. "L" is the letter symbol for _____.

11. When the current increases, _____ attempts to hold it down.

12. "Henry" is the unit of measure of _____.

13. Unit of inductive reactance is _____.

14. Symbol of inductive reactance is _____.

15. Inductive reactance is the opposition to the flow of changing current due to _____ _____.

16. In D. C. circuits _____ _____ occurs only when current is turned on or off.

17. In 60 cycle A. C. circuits, inductive reactance occurs _____ times per second.

18. _____ _____ is the amount in degrees by which the current lags the voltage.

19. The phase angle depends on _____ and _____.

20. Find the inductive reactance of a coil with an inductance of 15 henrys at 60 cycles.

21. Find the inductive reactance of a 15-henry coil at 120 cycles.

22. Find the voltage drop across a coil having an inductive reactance of 942 ohms and a 2-ampere current flow.

NAME _____ LESSON C-4

DATE _____ WORKSHEET

CAPACITANCE AND CAPACITIVE REACTANCE

1. The letter symbol for capacitance is _____.

2. The unit of capacitance is _____.

3. Capacitance is the _____ of a circuit to store electrical energy.

4. Two conducting materials separated by an insulating material are called _____ or _____.

5. In an A. C. circuit, a capacitor is constantly _____ and _____.

6. The effect of capacitance in an A. C. circuit is that it produces _____ to the flow of _____.

7. In a pure capacitive circuit, the current will lead the voltage by _____°.

8. One microfarad is _____ farad.

9. The total value of capacitors connected in parallel is the _____ of the capacities of the individual capacitors.

10. Find the total capacity in parallel of 15-uf, 45-uf, and 10-uf capacitors.

11. The symbol for capacitive reactance is _____.

12. The unit of capacitive reactance is _____.

13. The opposition to alternating current produced by capacitance is _____ _____.

14. Capacitive reactance is inversely proportioned to the product of the _____ and capacitance.

15. Phase angle is the amount in degrees by which the current _____ the voltage.

16. Small capacitor has a _____ reactance.

17. Large capacitor has a _____ reactance.

18. Find the capacitive reactance of a 10-uf capacitor at 60 cycles.

NAME _____ LESSON C-5

DATE _____ WORKSHEET

POWER FACTOR CORRECTION

1. A synchronous _____ is a synchronous motor used to correct power factor only and does not pull any _____ load.

2. Synchronous motors may be used to _____ low power factor of a system.

3. Lower power factors _____ the total current of a circuit.

4. Low power factor may be due to large power consumption by under-loaded _____ motors.

5. The true _____ is the actual power which may be measured by a watt meter.

6. Power factor is the ratio of power in watts to power in volt amperes. True/False _____

7. Find the capacitor rating necessary to raise the power factor to unity of an induction motor rated 7 1/2 HP at 440 volts. Draw vector diagram.

NAME _____ LESSON C-6

DATE _____ WORKSHEET

CAPACITORS

1. An installation of capacitors in which any single unit contains more than _____ gallons of combustible liquid shall be in a vault.

   (a) 3 (b) 4 (c) 5

2. Capacitor shall be provided with _____ - _____ cases and supports.

3. Capacitor cases shall be grounded in accordance with Article _____.

   (a) 250 (b) 460 (c) 680

4. The ampacity of capacitor circuit conductors shall be not less than _____ percent of the rated current of the capacitor.

   (a) 135 (b) 125 (c) 100

5. The continuous ampacity of the disconnecting device shall be not less than _____ percent of the rated current of the capacitor.

   (a) 100 (b) 125 (c) 135

6. List two means of capacitor discharge: _____

   _____

7. For greater power factor correction effect, the capacitor should be located at the _____.

8. An installation of capacitors for power factor correction will provide a reduction in power costs. True/False _____

9. Capacitors in hazardous locations shall comply with additional requirements in Articles _____ through _____.

10. When can the disconnecting means be omitted at the capacitor? _____

    _____

11. The current carrying capacity of a disconnecting device shall be a minimum of _____ percent of the rated current of the capacitor.

12. An overcurrent device shall be installed in each _____ conductor.

13. Is it necessary for the disconnecting means to open all ungrounded conductors simultaneously? _____

14. Are capacitor cases required to be grounded? _____

NAME _____ LESSON C-7

DATE _____ WORKSHEET

POWER IN AC CIRCUITS

1. The power in any electrical circuit is the product of _____ and _____ flowing at that time.

2. In a resistive circuit, power is found by multiplying the effective _____ by effective _____.

3. Apparent _____ is the product of the voltage and current.

4. Apparent power units are in _____ _____.

5. True power units are measured in _____.

6. Write the formula for finding true power in watts.

7. The ratio of true power to apparent power is called _____ _____.

8. Find the power factor of a motor drawing 500 watts and 5 amps from a 120-volt 60-cycle line.

9. Lights and motor loads of a store draw 32 kw. The power factor of this load is 75 percent. Find the apparent power delivered to the store.

10. In an inductive circuit, the reactive power _____ the true power.

11. In a capacitive circuit, the reactive power _____ the true power.

12. A three phase current consists of _____ alternating currents that _____ in phase by 120 degrees.

13. The currents in a three phase circuit will be _____ degrees out of phase with each other.

NOTE OF THANKS

This note will act as the acknowledgment for the reproduction of materials used as Information Sheets for "Hazardous Areas."

The revision committee wishes to thank the Crouse-Hinds Code Digest for the permission to use their series of "Hazardous Locations" information for instructional material in the Third Year Electrical Apprentice Technical Training.

The instructors and the students should profit by using this up-to-date information organized in such a compact and usable reference.

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Howard E. Hedinger
Educational Consultant

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I. Classification of Hazardous Atmospheres

A. Definitions.

The definitions below are extracted from the 1975 National Electrical Code. These definitions are included to define and clarify the meaning and intent of Crouse-Hinds when terms such as "Explosion-proof" and "Dust-ignition-proof" are used in this publication.

"Explosion-proof Apparatus": Apparatus enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor which may occur within it and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within, and which operates at such an external temperature that a surrounding flammable atmosphere will not be ignited thereby.

"Dust-ignition-proof," as used in this Article shall mean enclosed in a manner that will exclude ignitible amount of dusts or amounts that might affect performance or rating and that, where installed and protected in accordance with this Code, will not permit arcs, sparks, or heat otherwise generated or liberated inside of the enclosure to cause ignition of exterior accumulations or atmospheric suspensions of a specified dust on or in the vicinity of the enclosure.

The National Electrical Code, which is widely used for classification purposes, divides atmospheric explosion hazards into three broad classes; they are summarized in Table 1. However, it must be understood that considerable skill and judgment must be applied when deciding to what degree an area contains hazardous concentrations of vapors, combustible dusts or easily ignitible fibers and flyings. Many factors, such as temperature, barometric pressure, humidity, ventilation, distance from the vapor source, etc. must be considered. When information on all factors concerned is properly evaluated, a consistent classification for the selection and location of electrical equipment can be developed. For further information on classification of areas see NFPA 70C.

The table shown in Appendix I lists many of the hazardous compounds used in business and industry, with their classification, flash points, ignition temperatures, explosive limits and vapor densities.

B. The National Electrical Code and Underwriters Laboratories.

The NEC is considered the definitive classification tool and contains explanatory data about ethyl ether (Class I, Group C) as used in hospital operating rooms, and for gasoline (Class I, Group D) as it may apply to storage areas, garages and gasoline stations. Specific installation practices have been set up for these heavier-than-air vapors. However, there is no such specific data for acetylene, whose vapor density is very near that of air. In the case of hydrogen used indoors, since its vapor density is so low, the most hazardous concentrations are likely to be in the upper portion of the room. A safe approach to electrical installations in Group A & B atmospheres is to install Class I equipment, or consult local inspectors for ruling on area classification.

Most states, municipalities and public service companies use the NEC as a guide for their inspectors.

Underwriters' Laboratories, Inc. (U/L) is a not for profit, independent organization testing for public safety. Its function is to determine whether or not devices and materials submitted to it are safe and can be used in the NEC category for which they were designed. To do this, it maintains extensive laboratory and testing facilities.

U/L's function does not include actual enforcement of the National Electrical Code. However, as previously indicated, inspection authorities use U/L's listing as criteria in carrying out their inspections of hazardous areas.

C. Class I Atmospheric Hazards.

Class I atmospheric hazards are divided not only into the four groups shown in the table, but also into two divisions

Division 1 covers locations where flammable gases or vapors may exist under normal operating conditions, under frequent repair or maintenance operations, or where breakdown or faulty operation of process equipment might also cause simultaneous failure of electrical equipment.

Division 2 covers locations where flammable gases, vapors or volatile liquids are handled either in a closed system, or confined within suitable enclosures, or where hazardous concentrations are normally prevented by positive mechanical ventilation. Areas adjacent to Division 1 locations, into which gases might occasionally flow, would also belong in Division 2.

D. Class II Atmospheric Hazards.

Class II atmospheric hazards cover three groups of combustible dusts. Groups E and F are always Division 1. Group G may be either Division 1 or 2.

E. Class III Atmospheric Hazards.

Class III atmospheric hazards cover combustible fibers or flyings not likely to be in suspension in air in quantities sufficient to produce ignitable mixtures (Division 1.) and locations in which easily ignitable fibers are stored or handled (Division 2.).

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II. Prevention of External Ignition and Explosion

A. Sources of Ignition.

A source of energy is all that is needed to touch off an explosion when flammable gases or combustible dusts are mixed in the proper proportion with air.

One prime source of energy is electricity. Equipment such as switches, circuit breakers, motor starters, push button stations, or plugs and receptacles, can produce arcs or sparks in normal operation when contacts are opened and closed. This could easily cause ignition.

Next in degree of hazard are devices that produce heat, such as lighting fixtures and motors. Here, surface temperatures may exceed the safe limits of many flammable atmospheres. A loose lamp in a fixture socket presents a double hazard, as it may combine arcing with production of heat.

Finally, many parts of the electrical system can become potential sources of ignition in the event of insulation failure. This group would include wiring (particularly splices in the wiring), transformers, impedance coils, solenoids, and other low-temperature devices without make-or-break contacts.

Non-electrical hazards such as sparking metal can also easily cause ignition. A hammer, file or other tool that is dropped on masonry or on a ferrous surface is thus a hazard unless the tool is made of non-sparking material. For this reason, portable electrical equipment is usually made from aluminum or other material that will not produce sparks if the equipment is dropped.

Electrical safety, therefore, is of crucial importance. The electrical installation must prevent accidental ignition of flammable liquids, vapors and dusts released to the atmosphere. In addition, since much of this equipment is used outdoors or in corrosive atmospheres, the material and finish must be such that maintenance costs and shutdowns are minimized.

B. Combustion Principles.

Three basic conditions must be satisfied for a fire or explosion to occur:

1. A flammable liquid, vapor or combustible dust must be present in sufficient quantity.

2. The flammable liquid, vapor, or combustible dust must be mixed with air or oxygen in the proportions required to produce an explosive mixture.

3. A source of energy must be applied to the explosive mixture.

In applying these principles, the quantity of the flammable liquid or vapor that may be liberated and its physical characteristics must be recognized. For instance, lighter-than-air gases diffuse into the atmosphere so readily that, except in enclosed spaces, they may not produce hazardous mixtures in areas close to electrical installations.

Vapors from flammable liquids also have a natural tendency to disperse into the atmosphere, and rapidly become diluted to concentrations below the lower limit of the flammable (explosive) range, particularly when the air is moving.

The probability that the gas concentration may be above the upper limit of the explosive range does not afford any degree of safety, as the concentration must first pass through the explosive range to reach the upper limit.

C. Evaluation of Hazardous Areas.

Each area that contains gases or dusts that are considered hazardous must be carefully evaluated to make certain the correct electrical equipment is selected. Many hazardous atmospheres are Class I, Group D, or Class II, Group G. However, certain areas may involve other groups, particularly Class I, Groups B and C. Conformity with the National Electric Code requires use of fittings and enclosures approved for the specific hazardous gas or dust involved.

For Class I and Class II equipment see the Crouse-Hinds Construction Materials Catalog or your Crouse-Hinds field representative.

D. Intrinsically Safe Equipment.

The use of intrinsically safe equipment is primarily limited to process control instrumentation, since these electrical systems lend themselves to the low energy requirements. The NFPA 493-1969 provides information on the design, evaluation, and installation of this equipment. This document defines intrinsically safe equipment and wiring as:

Equipment and wiring that are incapable of releasing sufficient electrical energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture in its most easily ignited concentration.

Underwriters Laboratories, Inc. & Factory Mutual list several devices in this category. The equipment and its associated wiring must be installed so they are positively separated from the non-intrinsically safe circuits. Induced voltages could defeat the concept of intrinsically safe circuits.

II. Prevention of External Ignition and Explosion

E. Enclosures for Class I, Divisions 1 and 2 Conditions.

In both Division 1 and 2 of Class I locations, conventional relays, contactors and switches incorporating metal-to-metal contacts must be enclosed in explosion-proof housings.

By definition, enclosure for these locations must prevent the ignition of an explosive gas or vapor that may surround it. In other words, an explosion inside the enclosure must be prevented from starting a larger explosion on the outside.

Adequate strength is one requirement for such an enclosure. In most hazardous location designs for Class I, Divisions 1 & 2, a safety factor of 4 is used; i.e., the item must withstand a hydrostatic test of four times the maximum pressure from an explosion within the enclosure.

In addition to being strong, the enclosure must be "flame-tight." This term does not imply that the enclosure is hermetically sealed but rather that the joints or flanges are held within narrow U/L tolerances. These carefully machined joints cool the hot gases resulting from an internal explosion so that by the time they reach the outside hazardous atmosphere, they are too cool to effect ignition.

The strains and stresses caused by internal explosive pressures are illustrated in fig. 1. Dotted lines indicate shape that a rectangular enclosure strives to attain under these conditions. Openings in an enclosure for these applications can be threaded-joint type (fig. 2) or ground-joint type (fig. 3).

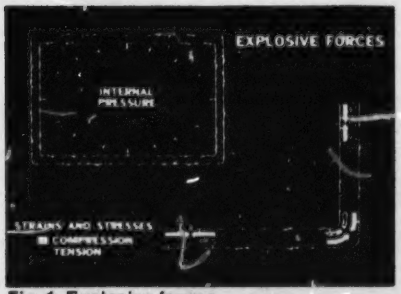


Fig. 1. Explosive forces.

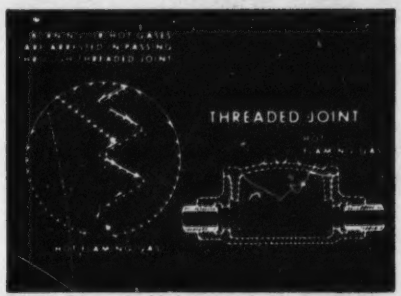


Fig. 2. Threaded joint opening.

Fig. 3. Ground joint opening.

F. Purging/Pressurization Systems.

Purging/Pressurization Systems permit the safe operation of electrical equipment under conditions of hazard for which approved equipment may not be commercially available.

For instance, most switchgear units and many large-size motors do not come in designs approved for Class I, Groups A and B.

Whether cast enclosures for hazardous locations or sheet metal enclosures with pressurization should be used is mainly a question of economics, if both types are available. As a typical example, if an installation had many electronic instruments that could be enclosed in a single sheet-metal enclosure, the installation would lend itself to the Purging/Pressurization System. However, if the instruments, due to their nature, had to be installed in separate enclosures, then the cast, hazardous location housing would almost invariably prove more economical.

Pressurized enclosures require:

- A source of clean air or inert gas.
- A compressor to maintain the required pressure on the system.
- Pressure control valves, to prevent the power from being applied before the cases have been purged, and to de-energize the system should pressure fall below a safe value.

In addition, door-interlock switches are required to prevent access to the equipment while the circuits are energized. It can readily be seen that all of these accessories can add up to a considerable expenditure.

For a detailed description of Purging/Pressurizing Systems see NFPA Bulletin 496 titled "Purged and Pressurized Enclosures for Electrical Equipment 1974". Or refer to the Canadian Electrical Code article entitled "A Suggested Method for Air Pressurizing Electrical Wiring Systems and Equipment in Class I Hazardous Locations, Appendix H, Rule 18-026, CEC Part I".

I. Classification of Hazardous Atmospheres

Table I **Summary of Hazardous Atmospheres** **(Based on National Electric Code and U/L)**

Class	Division	Group	Typical atmosphere/ignition temps.	Devices covered	Temperature measured	Limiting value
I Gases, vapors	1 Normally hazardous	A	acetylene (305C, 581F)	All electrical devices and wiring	Maximum external temperature in 40C ambient	See Sect. 500-2 of NEC
		B	butadiene[1] (420C, 788F) ethylene oxide[2] (429C, 804F) hydrogen (400C, 752F) manufactured gases containing more than 30% hydrogen (by volume) propylene oxide[2] (449C, 840F)			
		C	acetaldehyde (175C, 347F) cyclopropane (500C, 932F) diethyl ether (160C, 320F) ethylene (490C, 914F) unsymmetrical dimethyl hydrazine (UDMH 1, 1-dimethyl hydrazine) (249C, 480F)			
		D	acetone (465C, 869F) acrylonitrile (481C, 898F) ammonia[3] (651C, 1204F) benzene (560C, 1040F) butane (405C, 761F) 1-butanol (butyl alcohol) (365C, 689F) 2-butanol (secondary butyl alcohol) (405C, 761F) n-butyl acetate (425C, 797F) isobutyl acetate (421C, 790F) ethane (515C, 959F) ethanol (ethyl alcohol) (356C, 689F) ethyl acetate (427C, 800F) ethylene dichloride (413C, 775F) gasoline (56-60 octane: 280C, 536F) (100 octane: 456C, 853F) heptanes (280C, 536F) hexanes (225C, 437F) isoprene (220C, 428F) methane (natural gas) (482 to 632C, 900 to 1170F) methanol (methyl alcohol) (385C, 725F) 3-methyl-1-butanol (isoamyl alcohol) (350C, 662F) methyl ethyl ketone (516C, 960F) methyl isobutyl ketone (460C, 860F) 2-methyl-1-propanol (isobutyl alcohol) (427C, 800F) 2-methyl-2-propanol (tertiary butyl alcohol) (480C, 896F) petroleum naphtha[4] (288C, 550F) octanes (220C, 428F) pentanes (260C, 500F) 1-pentanol (amyl alcohol) (300C, 572F) propane (450C, 842F) 1-propanol (propyl alcohol) (440C, 824F) 2-propanol (isopropyl alcohol (399C, 750F) propylene (460C, 860F) styrene (490C, 914F) toluene (480C, 896F) vinyl acetate (427C, 800F) vinyl chloride (472C, 882F) xylenes (530C, 986F)			

I. Classification of Hazardous Atmospheres

Table I cont'd. **Summary of Hazardous Atmospheres† (Based on National Electrical Code)**

Class	Division	Group	Typical atmosphere/ignition temps.	Devices covered	Temperature measured	Limiting value
	2 Not normally hazardous	A	Same as Division 1	Lamps, resistors, coils, etc., other than arcing devices. (see Div. 1)	Max. internal or external temp. not to exceed the ignition temperature in degrees Celsius (°C) of the gas or vapor involved	See Sect. 500-2
		B	Same as Division 1			
		C	Same as Division 1			
		D	Same as Division 1 (Not normally hazardous means that the gases aren't normally present.)			
II Combustible dusts	1 Normally hazardous	E	Metal dust, including aluminum, magnesium, and their commercial alloys, and other metals of similarly hazardous characteristics.	Devices not subject to overloads (switches, meters)	Max. external temp. in 40C ambient with a dust blanket	No overload: E-200C (392F) F-200C (392F) G-165C (329F)
		F	Carbon black, coal, coke dust with more than 8% volatile material.	Devices subject to overload (motors, transformers)		Possible overload: E, F, G—120C (248F) but not to exceed no-overload values at overload
		G	Flour, starch, grain dusts.			
	2 Not normally hazardous	G	Same as Division 1	Lighting fixtures	Max. external temp. under conditions of use	Group: G—165C(329F)
III Easily ignitible fibers and flyings	1, 2			Lighting fixtures	Max. external temp. under conditions of use	165C (329F)

[1] Group D equipment shall be permitted for this atmosphere if such equipment is isolated in accordance with Section 501-5(a) by sealing all conduit ½-inch size or larger.

[2] Group C equipment shall be permitted for this atmosphere if such equipment is isolated in accordance with Section 501-5(a) by sealing all conduit ½-inch size or larger.

[3] For Classification of areas involving ammonia atmosphere, see Safety Code for Mechanical Refrigeration (ANSI B9.1-1971) and Safety Requirements for the Storage and Handling of Anhydrous Ammonia (ANSI K61.1-1972).

[4] A saturated hydrocarbon mixture boiling in the range 20—135°C (68—275°F). Also known by the synonyms benzine, ligroin, petroleum ether or naptha.

† For a complete list noting properties of flammable liquids, gases and solids refer to NFPA No. 325M-1969.

Appendix I

Hazardous Substances Used in Business and Industry

Crouse-Hinds Code Digest

Class I Group	Substance	Flash Point Degrees F	Flash Point Degrees C	Ignition Temp. Degrees F	Ignition Temp. Degrees C	Explosive Limits Per cent by Volume Lower	Explosive Limits Per cent by Volume Upper	Vapor Density (Air Equals 1.0)
C	acetaldehyde	−38	−38	347	175	4	60	1.5
D	acetone	0	−17	869	465	2.6	12.8	2.0
A	acetylene	gas	gas	581	305	2.5	100	0.9
D	acrylonitrile	32	0	898	481	3	17	1.8
D	ammonia	gas	gas	1204	651	16	25	0.6
D	benzene	12	−11	1040	560	1.3	7.1	2.8
B	butadiene	gas	gas	788	420	2	12	1.9
D	butane	gas	gas	761	405	1.9	8.5	2.0
D	1-butanol (butyl alcohol)	84	29	689	365	1.4	11.2	2.6
D	2-butanol (secondary butyl alcohol)	75	24	761	405	1.7 @ 212°F, 100°C	9.8 @ 212°F, 100°C	2.6
D	n-butyl acetate	72	22	797	425	1.7	7.6	4.0
C	cyclopropane	gas	gas	932	500	2.4	10.4	1.5
C	diethyl ether	−49	−45	320	160	1.9	36	2.6
D	ethane	gas	gas	959	515	3	12.5	1.0
D	ethanol (ethyl alcohol)	55	13	689	365	3.3	19	1.6
D	ethyl acetate	24	−4	800	427	2.2	11	3.0
C	ethylene	gas	gas	914	490	2.7	36	1.0
D	ethylene dichloride	56	13	775	413	6.2	16	3.4
B	ethylene oxide	<0	<−17	804	429	3.6	100	1.5
D	gasoline:							
	56-60 octane	−45	−48	536	280	1.4	7.6	3-4
	100 octane	−36	−38	853	456	1.4	7.4	3-4
D	heptanes	25-<32	−4 to 0	419-536	215-280	1.05	6.7	3.5
D	hexanes	−7	−22	437	225	1.1	7.5	3.0
B	hydrogen	gas	gas	752	400	4.0	75	0.1
D	isobutyl acetate	64	18	790	421	2.4	10.5	4.0
D	isoprene	−65	−54	428	220	2	9	2.4
D	methane (marsh gas)	gas	gas	1004	528	5	15	0.6
D	methanol (methyl alcohol)	52	11	725	385	6.7	36	1.1
D	3-methyl-1-butanol (isamyl alcohol)	109	43	662	350	1.2	9	3.0
D	methyl ethyl ketone	21	−6	960	516	1.8	10	2.5
D	methyl isobutyl ketone	73	23	860	460	1.4	7.5	3.5
D	2-methyl-1-propanol (isobutyl alcohol)	82	28	800	427	1.2 @ 212°F, 100°C	10.9 @ 212°F, 100°C	2.6
D	2-methyl-2-propanol (tertiary butyl alcohol)	52	11	896	480	2.4	8	2.6
D	octanes	56	13	428	220	1.0	6.5	3.9
D	pentanes	<−40	<−40	500	260	1.5	7.8	2.5
D	1-pentanol (amyl alcohol)	91	33	572	300	1.2	10 @ 212°F, 100°C	3.0
D	petroleum naphtha	<0	<−17	550	288	1.1	5.9	2.5
D	propane	gas	gas	842	450	2.2	9.5	1.6
D	1-propanol (propyl alcohol)	77	25	824	440	2.1	13.5	2.1
D	2-propanol (isopropyl alcohol)	53	12	750	399	2	12	2.1
D	propylene	gas	gas	860	460	2	11.1	1.5
B	propylene oxide	−35	−37			2.8	37	2.0
D	styrene	90	32	840	449	1.1	6.1	3.6
D	toluene	40	4	914	490	1.2	7.1	3.1
C	unsymmetrical dimethyl hydrazine (UDMH 1, 1-dimethyl hydrazine)	5	−15	480	249	2	95	2.0
D	vinyl acetate	18	−8	800	427	2.6	13.4	3.0
D	vinyl chloride	gas	gas	882	472	3.6	33	2.2
D	xylenes	81	27	986	530	1.1	7	3.7

Article 513 Aircraft Hangars

513-6. Stanchions, Rostrums, and Docks.

(a) IN HAZARDOUS LOCATION. Electric wiring, outlets, and equipment (including lamps) on or attached to stanchions, rostrums, or docks that are located or likely to be located in a hazardous location as defined in Section 513-2(c) shall comply with the requirements for Class I, Division 2 locations.

(b) NOT IN HAZARDOUS LOCATION. Where stanchions, rostrums, or docks are not located or likely to be located in a hazardous location as defined in Section 513-2(c), wiring and equipment shall comply with Sections 513-4 and 513-5, except that such wiring and equipment not more than 18 inches above the floor in any position shall comply with (a) above. Receptacles and attachment plugs shall be locking type that will not readily disconnect.

(c) MOBILE TYPE. Mobile stanchions with electric equipment complying with (b) above shall carry at least one permanently affixed warning sign to read: "WARNING —KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS."

513-7. Sealing.

Approved seals shall be provided in accordance with Section 501-5. Sealing requirements specified in Sections 501-5(a)(4) and 501-5(b)(2) shall apply to horizontal as well as to vertical boundaries of the defined hazardous locations. Raceways embedded in a masonry floor or buried beneath a floor shall be considered to be within the hazardous location above the floor where any connections or extensions lead into or through such location.

513-8. Aircraft Electrical Systems.

Aircraft electrical systems shall be de-energized when the aircraft is stored in a hangar, and, whenever possible, while the aircraft is undergoing maintenance.

513-9. Aircraft Battery— Charging and Equipment.

Aircraft batteries shall not be charged when installed in an aircraft located inside or partially inside a hangar.

Battery chargers and their control equipment shall not be located or operated within any of the hazardous areas defined in Section 513-2, and shall preferably be located in a separate building or in an area such as described in Section 513-2(d). Mobile chargers shall carry at least one permanently affixed warning sign to read: "WARNING—KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS." Tables, racks, trays, and wiring shall not be located within a hazardous location, and, in addition, shall comply with Article 480.

513-10. External Power Sources for Energizing Aircraft.

(a) NOT LESS THAN 18 INCHES ABOVE FLOOR. Aircraft energizers shall be so designed and mounted that all electric equipment and fixed wiring will be at least 18 inches above floor level and shall not be operated in a hazardous location as defined in Section 513-2(c).

(b) MARKING FOR MOBILE UNITS. Mobile energizers shall carry at least one permanently affixed warning sign to read: "WARNING—KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS."

(c) CORDS. Flexible cords for aircraft energizers and ground support equipment shall be approved for the type of service and extra-hard usage and shall include an equipment grounding conductor.

513-11. Mobile Servicing Equipment with Electric Components.

(a) GENERAL. Mobile servicing equipment (such as vacuum cleaners, air compressors, air movers, etc.) having electric wiring and equipment not suitable for Class I, Division 2 locations shall be so designed and mounted that all such fixed wiring and equipment will be at least 18 inches above the floor. Such mobile equipment shall not be operated within the hazardous location defined in Section 513-2(c) and shall carry at least one permanently affixed warning sign to read: "WARNING—KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS."

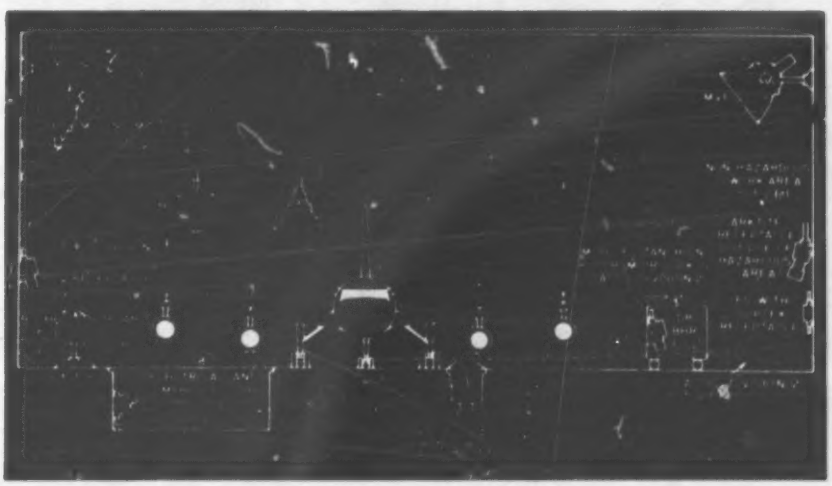
(b) CORDS AND CONNECTORS. Flexible cords for mobile equipment shall be suitable for the type of service and approved for extra-hard usage, and shall include an equipment grounding conductor. Attachment plugs and receptacles shall be approved for the location in which they are installed, and shall provide for connection of the grounding conductor to the raceway system.

(c) RESTRICTED USE. Equipment not suitable for Class I, Division 2 locations shall not be operated in locations where maintenance operations likely to release flammable liquids or vapors are in progress.

513-12. Grounding.

All metal raceways and all noncurrent-carrying metal portions of fixed or portable equipment, regardless of voltage, shall be grounded as provided in Article 250.

Recommended installation for aircraft hangars



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Article 514 Gasoline Dispensing and Service Stations

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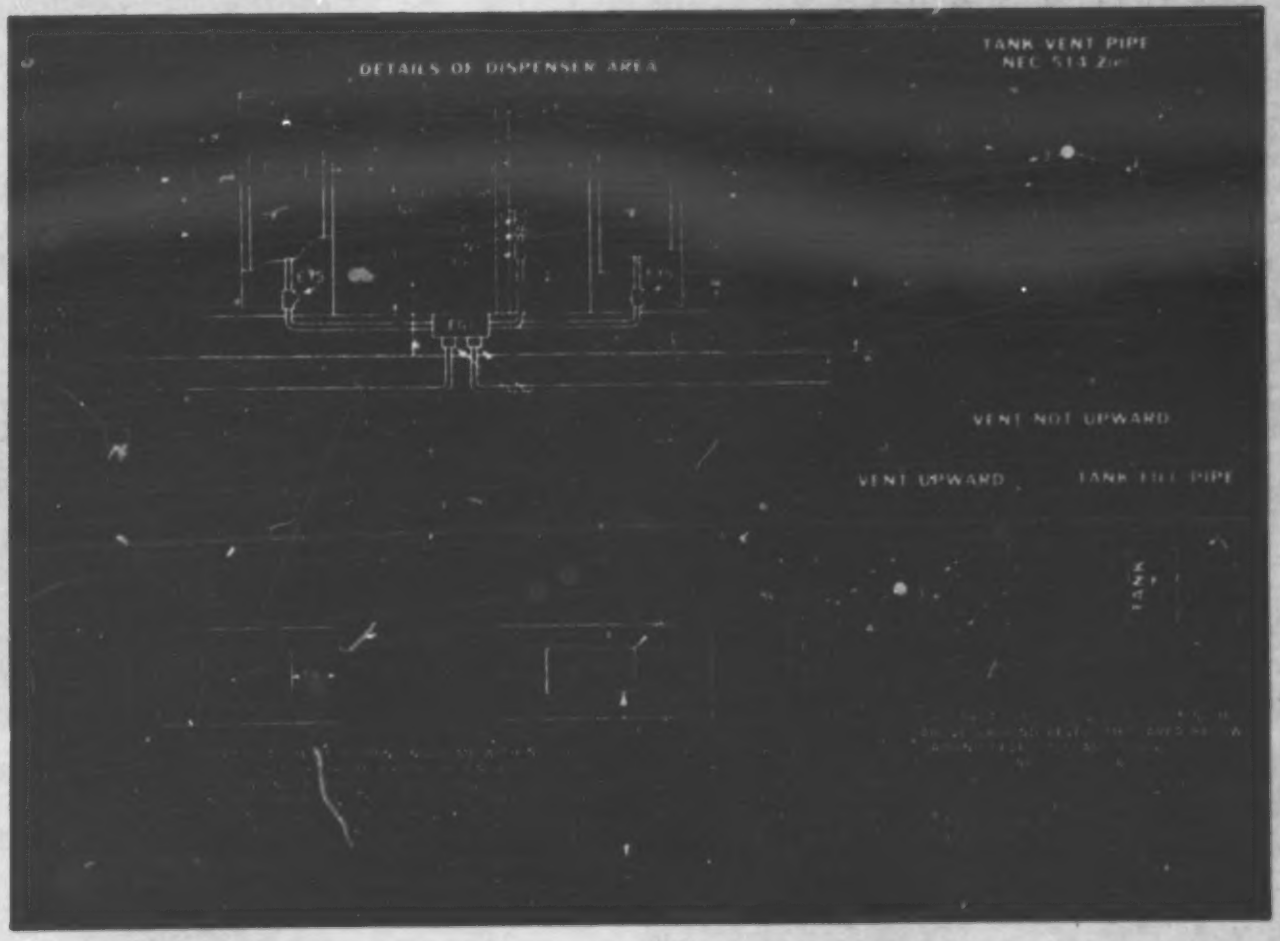
◀ Pole standard within 20 ft. horizontally from any dispensing island or pump, or from any tank fill-pipe or tank vent-pipe is Class I, Division 2. See 514-2(b).

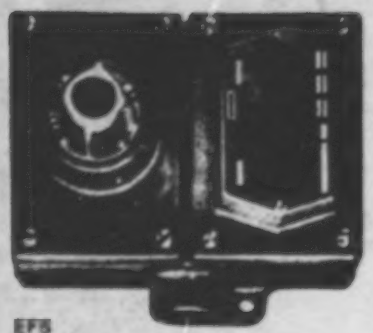
▶ A building less than 20 ft. from any island, pump, tank fill-pipe, or tank vent-pipe is a Class I, Division 2 location up to 18 inches above grade.

Note
If a building is over 20 feet from any island, pump, tank fill-pipe, or tank vent-pipe it is not a hazardous location. But in either case seals must be placed in all underground conduits to prevent explosions in conduits from reaching panelboard. See 514-6 (a) and (b).

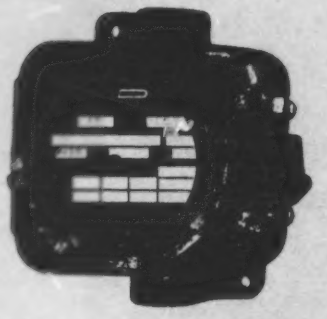


Article 515
Bulk-Storage Plants

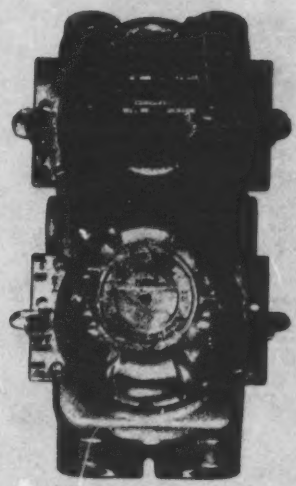
Crouse-Hinds Code Digest



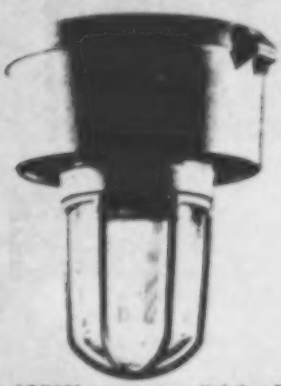
EF5
Push button station and pilot light



GUSC Enclosure with switch circuit breaker or manual starter



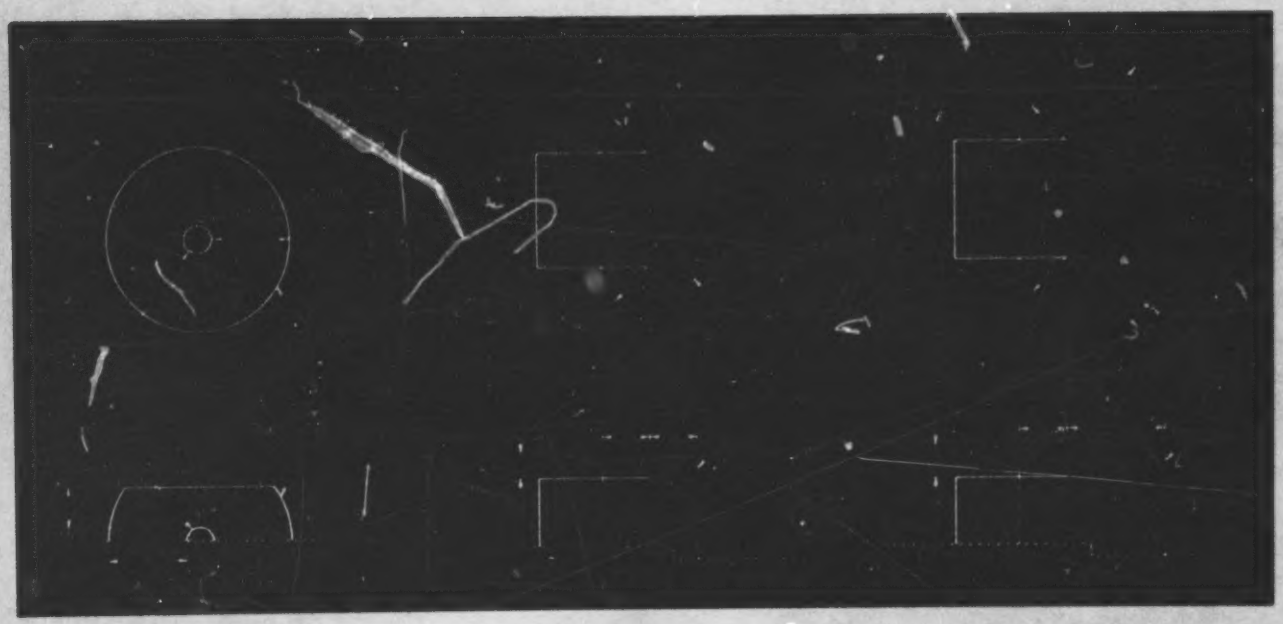
GUSC
Combination manual starter and circuit breaker enclosure



VMV Mercury vapor lighting fixture

VXHT Incandescent lighting fixture

Note: The VMV and VDC fixtures are suitable for Class I, Div. 2. All other enclosures on these two pages are suitable for use in Class I, Division 1 locations in bulk storage plants.



(4) For spraying operations confined to an enclosed spray booth, the space within 3 feet in all directions from any openings in the spray booth.

(5) All space within the room but beyond the limits for Class I, Division 1 as defined in Section 516-2(a) for dip tanks and drain boards, and for other hazardous operations.

(c) ADJACENT LOCATIONS. Adjacent locations that are cut off from the defined hazardous locations by tight partitions without communicating openings, and within which hazardous vapors are not likely to be released, shall be classified as nonhazardous unless the authority having jurisdiction judges otherwise.

(d) NONHAZARDOUS LOCATIONS. Locations utilizing drying, curing, or fusion apparatus and provided with positive mechanical ventilation adequate to prevent formation of flammable concentrations of vapors, and provided with effective interlocks to de-energize all electric equipment (other than equipment approved for Class I locations) in case the ventilating equipment is inoperative, may be classified as nonhazardous where the authority having jurisdiction so judges.

For further information regarding safeguards, see Ovens and Furnaces, Design, Location and Equipment (NFPA No. 86A-1973).

516-3. Wiring and Equipment in Hazardous Locations.

(a) WIRING AND EQUIPMENT—VAPORS. All electric wiring and equipment within the hazardous location (containing vapor only—not residues) defined in Section 516-2 shall comply with the applicable provisions of Article 501.

(b) WIRING AND EQUIPMENT—VAPORS AND RESIDUES. Unless approved for both readily ignitible deposits and the flammable vapor location, no electric equipment shall be installed or used where it may be subject to hazardous accumulations of readily ignitible deposits or residues, as the susceptibility to spontaneous heating and ignition of some residues may be greatly increased at temperatures above normal. Type MI cable and wiring in threaded rigid metal conduit may be installed in such locations, if the explosion-proof boxes or fittings contain no taps, splices, or terminal connections that may possibly become loose in service and thereby cause abnormal temperatures on external surfaces of boxes or fittings.

(c) ILLUMINATION. Illumination of readily ignitible areas through panels of glass or other transparent or translucent material shall be permitted only if it complies with the following: (1) fixed lighting units are used as the source of illumination; (2) the panel effectively isolates the hazardous location from the area in which the lighting unit is located; (3) the lighting unit is approved for its specific location; (4) the panel is of a material or is so protected that breakage will be unlikely; and (5) the arrangement is such that normal accumulations of hazardous residue on the surface of the panel will not be raised to a dangerous temperature by radiation or conduction from the source of illumination.

(d) PORTABLE EQUIPMENT. Portable electric lamps or other utilization equipment shall not be used within a hazardous location during operation of the finishing process. When such lamps or utilization equipment are used during cleaning or repairing operations, they shall be of a type approved for Class I, Group D, Division 1 locations, and all exposed metal parts shall be effectively grounded.

(e) ELECTROSTATIC EQUIPMENT. Electrostatic spraying or detearing equipment shall be installed and used only as provided in Section 516-4.

For further information, see NFPA Standard for Spray Application Using Flammable and Combustible Materials (NFPA No. 33-1973).

516-4. Fixed Electrostatic Equipment.

This Section shall apply to any equipment using electrostatically charged elements for the atomization, charging, and/or

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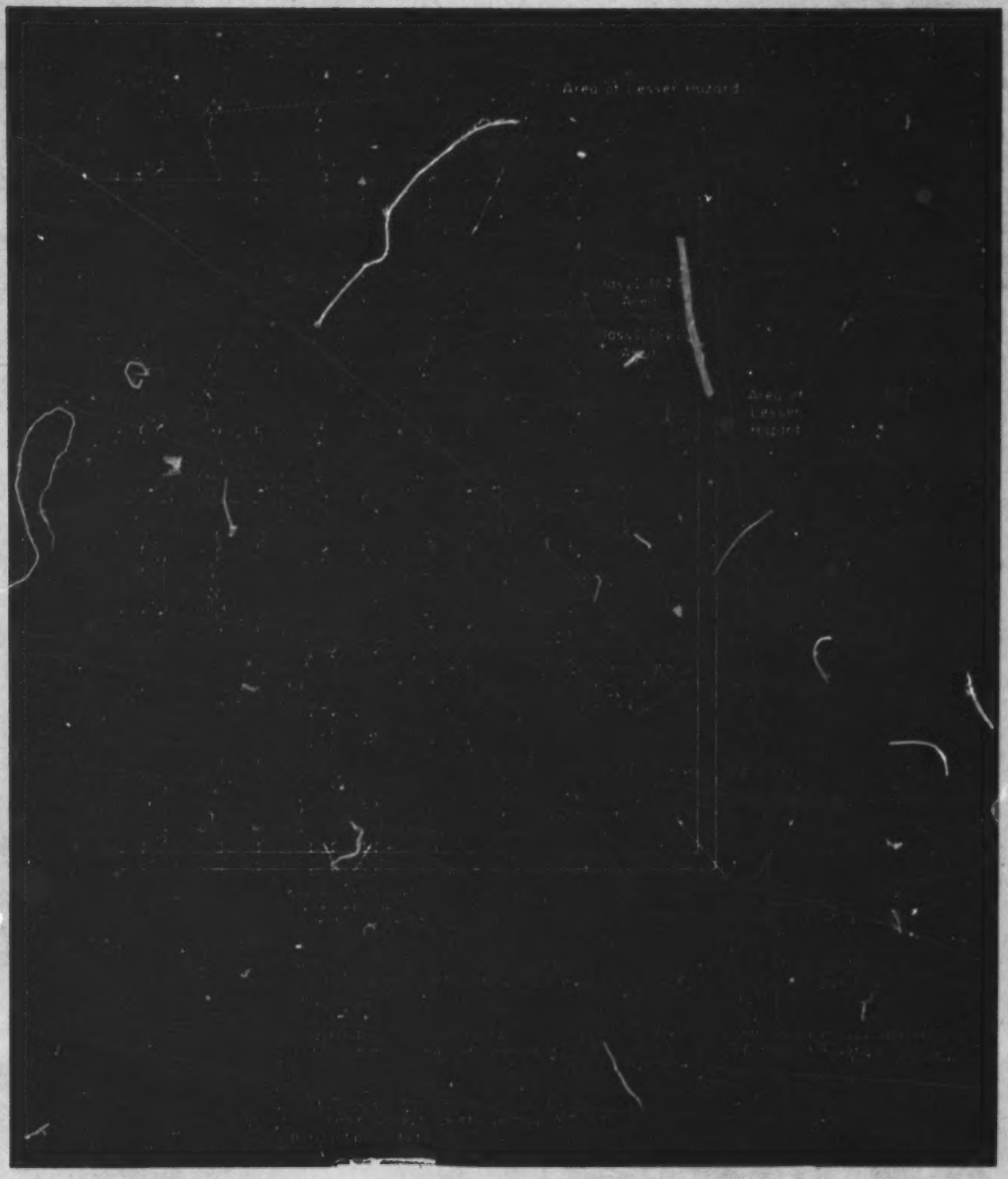


Appendix V

Diagram for Class I, Div. 1 Lighting Installation

Crouse-Hinds Code Digest

Key to Numerals

1 Sealing fitting. EYS for horizontal or vertical.
2 Sealing fitting. EZS for vertical or horizontal conduits.
3 Circuit breaker. Type EPC.
4 Panelboard. EDP. Branch circuits are factory sealed. No seals required in mains or branches unless 2" or over in size.
5 Junction box. Series GUA, GUB, GUJ, have threaded covers. Series CPS has ground flat surface covers.
6 Fixture hanger. EFHC, GUAC or EFH.
7 Lighting fixture. EV series.
8 Flexible fixture support. ECGH or EFH.
9 Fluorescent fixture. EVF.
10 Float switch. EMS.
11 Signal. ETH horns and sirens. ESR Bells.
12 Visualarm EKP.
13 Plug receptacle. CES-delayed action.
14 Plug receptacle. FSQ. Interlocked with switch.
15 Breather. ECD.
16 Drain. ECD.
17 Union. UNY.
18 Switch. Series EFS.
19 Manual line starter. FLF.
20 Manual line starter. GUSC.
21 Motors. explosion-proof.

National Electrical Code References

a Par. 501-5a-4. Seal required where conduit passes from hazardous to non-hazardous area.
b Par. 501-5a-1. Seals required within 18 inches of all arcing devices.
c Sec. 384-16. Circuit breaker or rating not greater than rating of panelboard required if supply conductors have overcurrent protection over 200 amperes.
d Par. 501-5a-2. Seals required if conduit is 2 inches or larger.
e Par. 501-6a. All arcing devices must be explosion-proof.
f Par. 501-4a. All boxes must be explosion-proof and threaded for rigid conduit.
g Par. 501-9a-4. All boxes and fittings for support of lighting fixtures must be approved for the purpose.
h Par. 501-9a-1. All lighting fixtures fixed or portable must be explosion-proof.
i Par. 501-9a-3. Pendent fixture stems must be threaded rigid conduit or approved flexible connector. Rigid stems if over 12 inches must have flexible connector, or must be braced.
j Sec. 501-14a. All signal circuits irrespective of voltage must be approved for Class I location.
k Sec. 501-12. Receptacles and plugs must be explosion-proof and provide grounding connections for portable equipment.
l Par. 501-5f. Breathers and drains needed in all humid locations.
m Par. 501-4a. All joints and fittings must be explosion-proof.
n Par. 501-8a. Motor must be suitable for Class I.
p Art. 430. Motor overcurrent protection.

Appendix VI

Diagram for Class I, Div. 1 Power Installation

Key to Numerals

1 Sealing fitting. EYS for horizontal or vertical.

2 Sealing fitting. EZS for vertical or horizontal conduits.

3 Circuit breaker EPC.

4 Junction box series GUA, GUB and GUJ have threaded covers. Series CPS and Type LBH have ground flat surface covers.

5 Circuit breaker FLB.

6 Manual line starter FLF.

7 Magnetic line starter GUB.

8 Combination circuit breaker and line starter EPC.

9 Switch or motor starter. Series EFS or GUSC.

10 Push button station. Series EFS or OFC.

11 Breather. ECD.

12 Drain. ECD.

13 Union. UNF.

14 Union. UNY.

15 Flexible coupling. ECH.

16 Plug receptacle. CES. Factory sealed.

17 Motor for hazardous location.

National Electrical Code References

a Par. 501-5a-3. Seals required where conduits pass from hazardous to non-hazardous area.

b Par. 501-5a-1. Seals required within 18 inches of all arcing devices.

c Art. 430 should be studied for detailed requirements for conductors, motor feeders, motor feeder and motor branch circuit protection, motor overcurrent protection, motor controllors and motor disconnecting means.

d Par. 501-5a-2. Seals required if conduit is 2 inches or larger in size.

e Par. 501-4a. All boxes must be explosion-proof and threaded for rigid conduit.

f Par. 501-6a. Push button stations must be explosion-proof.

g Par. 501-5d. Breathers and drains needed in all humid locations.

h Par. 501-4a. All joints and fittings must be explosion-proof

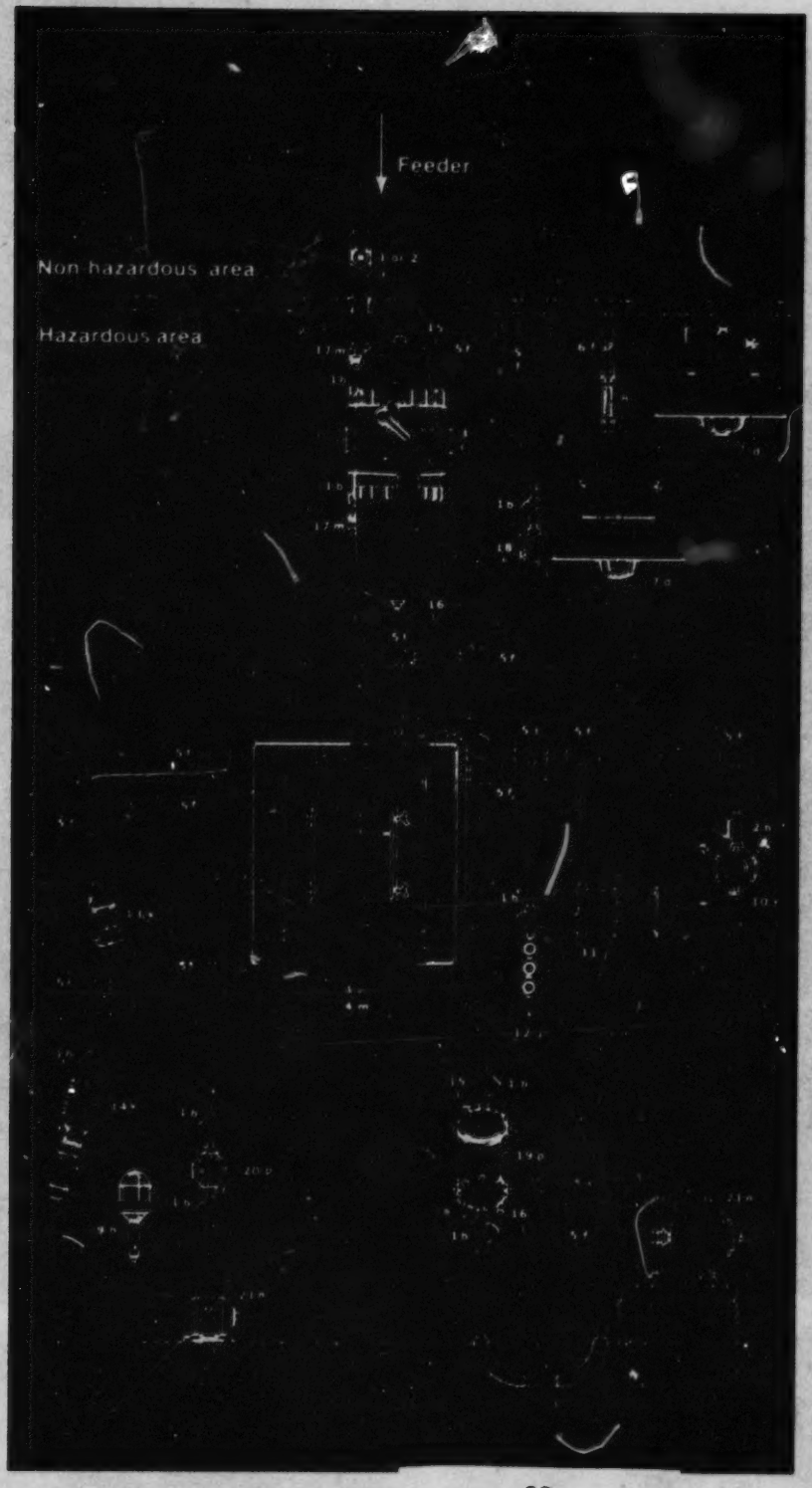
i Par. 501-4a. Flexible connections must be explosion-proof.

j Sec. 501-12. Receptacles and plugs must be explosion-proof, and provide grounding connections for portable devices.

Appendix VI

Diagram for Class I, Div. 2 Power and Lighting Installation

Crouse-Hinds Code Digest

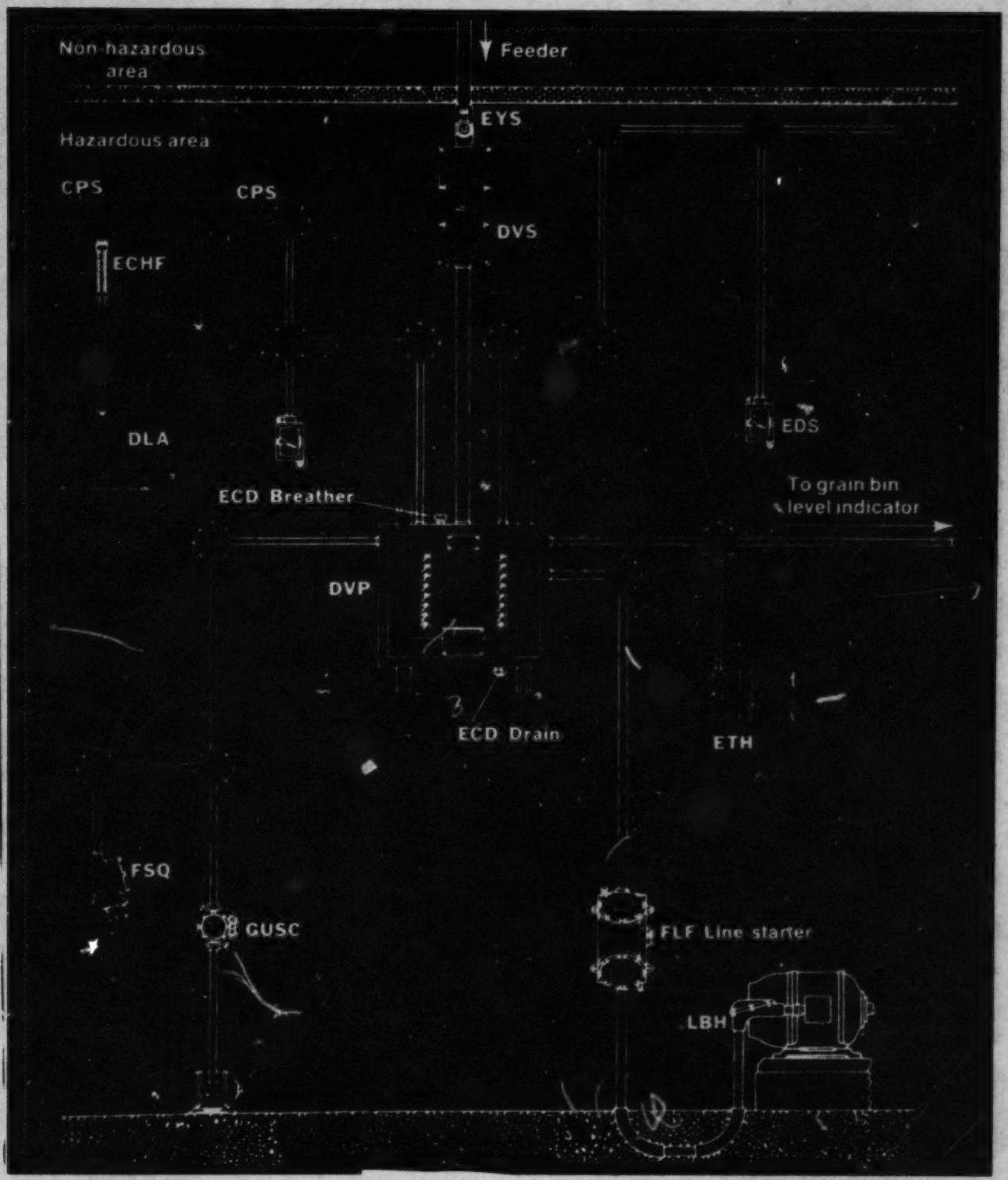


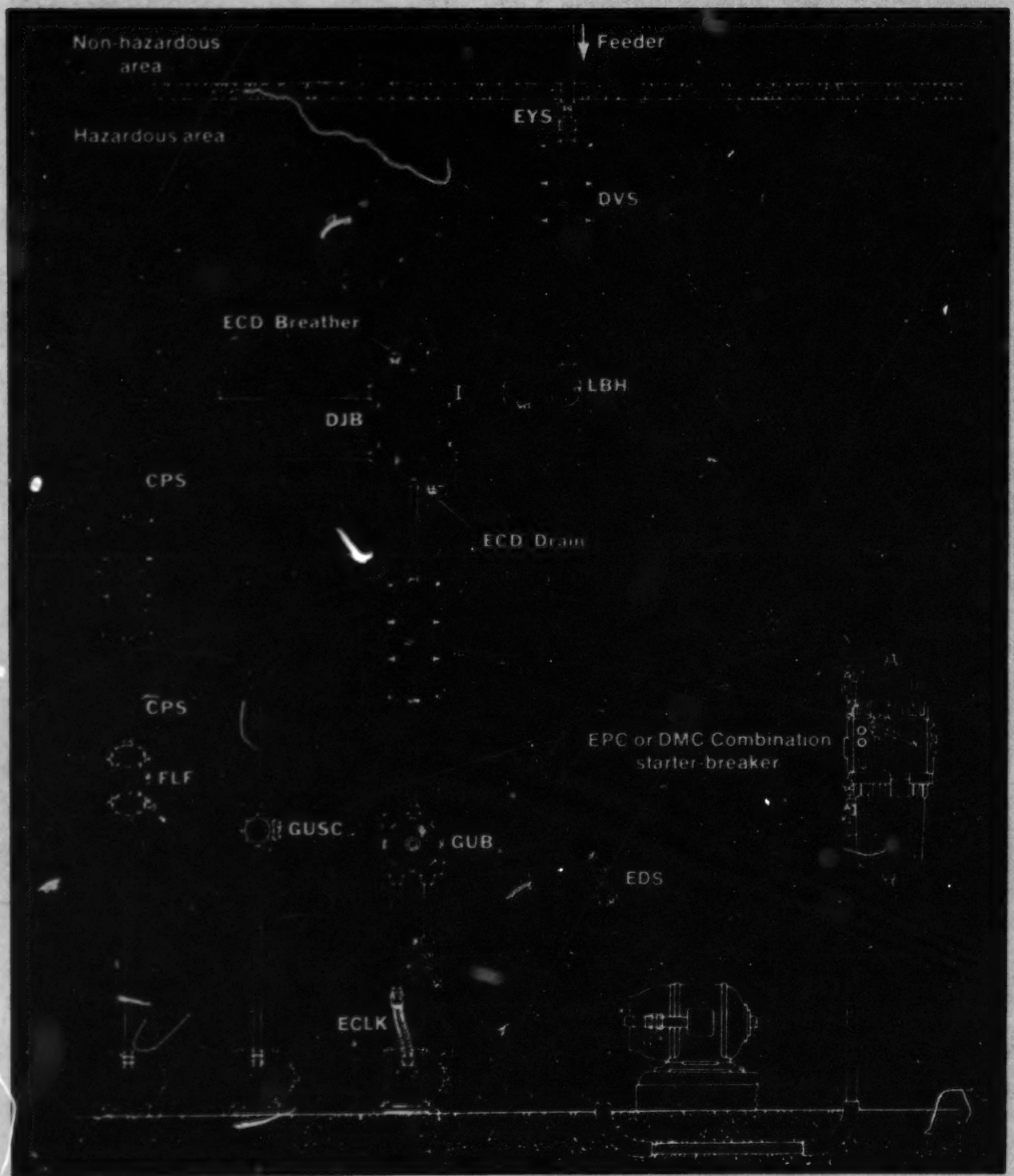
Key to Numerals

1 Sealing fitting. EYS for horizontal or vertical.
2 Sealing fitting. EZS for vertical or horizontal conduits.
3 Circuit breaker. Type EPC.
4 Panelboard. D2PB, N2PB. Branch circuits are factory sealed.
5 Junction box or conduit fitting. NJB, obround.
6 Fixture hanger. AHG, GS, UNJ.
7 Lighting fixture. VMV (Relamp Champ).
8 Flexible fixture support.
9 Handlamp. EVH.
10 Float switch. EMS.
11 Signal. ETH horns and sirens. ESR Bells.
12 Visualarm EKP.
13 Plug receptacle. CES-delayed action.
14 Plug receptacle. FSQ. Interlocked with switch.
15 Breather. ECD.
16 Drain. ECD.
17 Union. UNY.
18 Switch. Series EFS.
19 Manual line starter. FLF.
20 Manual line starter. GUSC.
21 Motors. Suitable for Class I locations.

National Electrical Code References

a Par. 501-5b-2. Seal required where conduit passes from hazardous to non-hazardous area.
b Par. 501-5b-1. Seals required within 18 inches of all arcing devices.
c Sec. 384-16. Circuit breaker or rating not greater than rating of panelboard required if supply conductors have overcurrent protection over 200 amperes.
d Par. 501-9b-2. All fixed lighting fixtures shall be enclosed and gasketed and not exceed ignition temperature of the gas.
e Par. 501-6b1. All arcing devices must be explosion-proof.
f Par. 501-4b. All boxes must be threaded for rigid conduit.
g Par. 501-9b-4. All boxes and fittings for support of lighting fixtures must be approved for the purpose.
h Par. 501-9b-1. All portable lighting fixtures must be explosion-proof.
i Par. 501-9b-3. Pendent fixture stems must be threaded rigid conduit or approved flexible connector. Rigid stems if over 12 inches must have flexible connector, or must be braced.
j Sec. 501-14-b. All signalling equipment must be approved for Class I location.
k Sec. 501-12. Receptacles and plugs must be explosion-proof and provide grounding connections for portable equipment.
l Par. 501-5f. Breathers and drains needed in all humid locations.
m Par. 501-4b. All joints and fittings are not required to be explosion-proof.
n Par. 501-8b. Motor shall be suitable for Div. 2.
p Art. 430. Motor overcurrent protection.


Non-hazardous area
Feeder
EYS
Hazardous area
CPS
CPS
DVS
ECHF
DLA
EDS
ECD Breather
To grain bin level indicator
DVP
ECD Drain
ETH
FSQ
GUSC
FLF Line starter
LBH


Non-hazardous area
Feeder
Hazardous area
EYS
DVS
ECD Breather
LBH
DJB
CPS
ECD Drain
CPS
EPC or DMC Combination starter-breaker
FLF
GUSC
GUB
EDS
ECLK

Crouse-Hinds Code Digest

Appendix IX

"Quick-Selector" Electrical Equipment for Hazardous Locations

Note: Not all types listed are suitable for use in all four groups of Class I hazardous locations. Consult catalog listing pages for applicable classes and groups.

	Class I Div. 1	Class I Div. 2	Class II Div. 1		Class II Div. 2 (Group G only)	Class III Div. 1	Class III Div. 2
			Group E & F	Group G			
Conduit outlet bodies and junction boxes	CPS EJB EKC GUB GUJ EAB EJH GUA GUF LBH	Form 7 Series, etc., . W Series	CPS EJB EKC GUB GUJ EAB EJH GUA GUF LBH	Same if splices, taps, etc.	Form 7 Series, etc., W Series		
Switches	EDS, EFD, EFS, FLS, FSPC, GUSC, OFC						
Panelboards	EDP ESPB GUSC	EDP ESPB GUSC D2PB	DLP, DVP				
Lighting fixtures	EV EVAM EVF Hazard-Gard RCDE	Vaporgard V Series VDB VMV VMVC VMVM VMVS FVN	DL DLAM EVF FDV		Vaporgard V Series VDB VMV VMVC VMVM VMVS FVN		
Fixture hangers	COUP CPS EAHC EC EFHC GUA	AHG EC GS UNE UNH UNJ UNJC	CPS EC EAHC EFHC GUA		AHG EC GS OSA	AHG AL EC GS OSA UNJ UNJC	
Plugs and receptacles	APJ, CES, CESD, CPH, CPP, CPS, EHS, ESW, BHR, BHP, DR, EHR, FP, FSQ, SRD, SP		Group G only APJ, BHR, BHP, DR, FP, FSQ, SRD, SP		Arktite Arktrol		
Interlocked plug receptacles	EPC, FSQ		Group G only FSQ, EPC, DBR			FSQ, EPC, DBR	
Control stations and pilot lights	EDS, EFD, EFS, EGP, EMP, EWC, OAC, OFC						
Industrial control	BMC, EDS, EFD, EFS, EPC, EPCB, FLF, FSPC, GUB, GUSC, OFC						
Circuit breakers	EDS, EFD, EPC, EPCB, FLB, GUSC		DVS, EDS, EFD, EPC, FLB, GUSC				
Telephones, instruments and signals	ECT, EKP, EMH, ESR, ET Telephones, ETH, GUB (plus WH (A.C. only) for Class II, Div. 2 and Class III, Div. 1 and 2)						

NAME _____ LESSON C-8

DATE _____ WORKSHEET

HAZARDOUS LOCATIONS

1. Do Articles 500 - 517 apply to hazardous locations if intrinsically safe equipment and wiring is used? Yes/No _____. Give the N.E. Code Section to prove your answer. _____

2. Define "intrinsically safe" equipment. _____

_____

_____

3. Define the three classes of hazardous locations:

I. _____

II. _____

III. _____

4. List the class and group classification for the following areas:

	CLASS	DIVISION	GROUP
(a) Ethylene			
(b) Starch			
(c) Gasoline			
(d) Acetylene			
(e) Benzol			
(f) Hydrogen			
(g) Coal			
(h) Aluminum Dust			
(i) Lacquer Solvent Vapors			
(j) Flour			
(k) Rayon			

5. Where may hazardous materials be found in a Division 1 area?

_____

6. Where may hazardous materials be found in a Division 2 area?

_____

7. What type hazardous location requires the installation of wiring in threaded rigid metal conduit with explosion-proof fitting or Type "MI" cable? _____

8. What type wiring installation is required in a Class III, Division I location? _____

9. What type wiring installation is required in a Class II, Division 1 location? _____

_____

10. Electrical metallic tubing may be used in Class _____, Division _____ location.

11. What type wiring installation is required in a Class I, Division II location? _____

_____

12. Where it is impractical to make a threaded joint tight, _____ _____ shall be utilized.

13. What is the intent of Article 500 through 503? _____

_____

_____

_____

14. Where are the definitions of "approved," "explosion-proof," and "dust-ignition proof" found in the N. E. Code?

_____

15. What markings will show on "approved" equipment to be used in hazardous locations?

(a) _____

(b) _____

(c) _____

16. The temperature range of an item of equipment is based on an ambient of _____° C.

NAME _____ LESSON C-9

DATE _____ WORKSHEET

CLASS I INSTALLATIONS

(HAZARDOUS LOCATIONS)

1. List two construction requirements for vaults containing transformers and capacitors not containing a liquid that will burn installed in Class I, Division 1, locations:

   (a) _____

   (b) _____

2. Installation of transformers and capacitors in Class I, Division 2, locations requires only standard code requirement as covered in sections _____ to _____.

3. Rigid threaded _____ _____ or Type _____ cable shall be installed in Class I, Division 1, locations.

4. All boxes, fittings, and joints shall be _____ and shall be _____ _____ in Class I, Division 1, locations.

5. In Class I, Division 2, locations, Type _____ cable or threaded _____ _____ _____ shall be installed.

6. What is the purpose of using seals? _____

   _____

7. Seals shall not exceed _____ inches from enclosure in Class I, Division 1, locations.

8. Are seals required in conduits less than 2 inches diameter in Class I, Division 1, locations? _____

9. In conduits leaving Class I, Division 1, areas, seals may be installed either _____ or _____ the hazardous area.

10. If the seal is installed inside the hazardous area of a Class I, Division 1, location, there shall be no _____, _____, _____, or _____ in conduit between seal fitting and the point at which the conduit leaves the hazardous area.

11. Explosion-_____ flexible motor fittings shall be used in Class I, Division 1, locations.

12. The thickness of compound in seal fittings shall not be less than _____ inch.

13. Splices and _____ shall not be made in sealing fittings.

14. In Class I, Division 2, locations, a disconnecting switch may be of the _____ _____ type.

15. List the two conditions under which a panelboard with a general purpose enclosure may be installed in a Class I, Division 2, area.

    (a) _____

    _____

    (b) _____

    _____

16. Flexible cord with a ground conductor may be used in Class I, Division ___& ___ wiring.

17. Motors shall be _____ _____ or _____ _____ type for Class I, Division 1, locations.

18. Lighting fixtures in Class I, Division 1, locations shall be approved as a _____ assembly.

19. Stems for pendant fixtures in Class I, Divisions 1 and 2 locations, shall not exceed _____ inches without permanent bracing.

20. List two required methods of protecting lighting fixtures in Class I, Division 1, areas:

    (a) _____

    (b) _____

21. Flexible cords may be used for connection to portable _____ in Class I, Divisions 1 and 2, locations.

22. List two requirements for using receptacles in Class I, Divisions 1 and 2, locations:

    (a) _____

    (b) _____

NAME _____ LESSON C-9

DATE _____ WORKSHEET

23. In Class I, Divisions 1 and 2 locations, conductor insulation shall be protected by a sheath of _____ where condensed vapors or liquids may collect on conductors.

24. All exposed non-current-carrying metal parts of electrical equipment shall be _____ in Class I, Divisions 1 and 2 locations.

25. In Class I, Divisions 1 and 2, there shall be no _____ live parts.

26. Grounding requirements in Class I, Division I and II locations are (more or less) _____ restrictive than in article 250. These requirements are found in _____.

NAME _____ LESSON C-10

DATE _____ WORKSHEET

CLASS II INSTALLATIONS

(HAZARDOUS LOCATIONS)

1. Class II locations are those which are hazardous because of the presence of _____ _____.

2. Explosion-proof equipment is not acceptable in Class _____ installations unless approved for such locations.

3. Describe the meaning of "dust-ignition-proof" as used in Article 502.

_____

_____

_____

4. Generally the maximum surface temperatures under actual operating conditions permitted under this article for equipment not subject to overloading is _____°C (_____°F).

5. Generally the maximum surface temperature permitted under this article for a motor is _____°C (_____°F).

6. List three construction requirements for vaults containing transformers, containing a liquid which will burn, installed in Class II, Division 1, locations:

   (a) _____

   (b) _____

   (c) _____

7. Is it necessary to install a capacitor, not containing a liquid that will burn, in a vault in Class II, Division 1, area? _____

   _____

8. No transformer shall be installed in a production area for _____ powder.

9. List two conditions under which a dry-type transformer may be installed without a vault in a Class II, Division 1, area:

   (a) _____

   (b) _____

10. All Class II, Divisions 1 and 2, shall be protected from _____ voltage surges using _____ protective devices, _____ of all grounds and _____ protective capacitors.

11. In Class II, Division 1, installations, threaded rigid _____ _____ and Type _____ cable shall be installed.

12. Fitting and boxes in Class II, Division 1, areas shall be _____ - _____ proof and approved for _____ _____ locations.

13. EMT is permitted as a _____ in Class II, Division 2, areas.

14. List two wiring methods where seals may be omitted in Class II, Divisions 1 and 2, areas:

    (a) _____

    (b) _____

15. Circuit breaker enclosures in Class II, Division 1, areas shall be _____ - _____ _____.

16. Motors in Class II, Division 1, areas shall be _____ _____ nonventilated and shall be approved as _____ - _____ _____ for _____ _____ locations.

17. Motors in Class II, Division 2, areas _____ _____.

18. Ventilating piping for electrical equipment shall be constructed of metal no lighter gauge than No. _____ USS.

19. Lighting fixtures for Class II, Division 1, areas shall be _____ - _____ _____ approved for Class _____ installation.

20. Maximum pendant length for lighting, fixtures in Class II, Division 1, areas shall be _____ inches.

21. On chain-mounted pendant fixtures, _____ shall be installed at the entrance of cord with outlet box and fixture.

22. List two conditions which a lighting fixture is acceptable in a Class II, Division 2, area even though it is not approved for a Class II installation:

    (a) _____

    _____

    (b) _____

    _____

23. Fluorescent lamps conforming to requirements may be installed in Class _____, Division _____ areas.

NAME _____ LESSON C-10

DATE _____ WORKSHEET

24. List two requirements for installing receptacles and plugs in Class II, Division 1, areas:

    (a) _____

    (b) _____

25. What is the difference between the requirements for installing a receptacle in a Class II, Division 2, area, and a Class II, Division 1 area? _____
    _____
    _____

26. In a Class II Division I location, is it necessary to always install communication wiring in a metal raceway or use Type MI cables? _____

27. There shall be no exposed _____ parts in Class II, Divisions 1 and 2, areas.

28. In Class II, Divisions 1 and 2, all exposed non-current carrying metal parts shall be _____.

29. Bonding _____ shall be installed for bonding purposes in Class II, Divisions 1 and 2, installations.

NAME _____ LESSON C-11

DATE _____ WORKSHEET

CLASS III INSTALLATIONS

(HAZARDOUS LOCATIONS)

1. Class III locations are hazardous due to the presence of _____ _____ and _____.

2. Rigid _____ _____ or Type _____ (also MC,CS or "ALS") cable shall be installed in Class III, Division I areas.

3. Flexible connections shall be made with _____ - _____ connectors in Class III, Division ____ and _____ areas.

4. Open _____ may be installed in Class III, Division 2 locations, used soley for storage and containing no machinery.

5. Partially enclosed type or _____ - _____ motors shall not be installed in Class III locations.

6. Maximum pendant length on a lighting fixture is _____ inches in a Class III location.

7. Electric - _____ lighting fixtures with guard may be installed in Class III locations.

8. In Class III locations, the power supply for cranes shall be _____ from all other systems and _____.

9. Recording _____ _____ shall be installed on crane systems in Class III locations.

10. Storage battery charging equipment shall be installed in _____ _____ in Class III locations.

11. In Class III installations, all exposed non-current-carrying metal parts shall be _____.

12. There shall be no exposed live parts in Class III areas except for _____ _____ and _____ and _____ _____, installations

13. List two conditions for receptacles and plugs for Class III areas:

    a. _____

    b. _____

14. In general, _____ enclosed motors shall be installed in all Class III areas.

15. List two requirements for construction of lighting fixtures in Class III areas:

    a. _____

    b. _____

16. Maximum surface temperature of a lighting fixture shall not exceed _____ °C (329°F) under normal conditions of use.

NAME _____ LESSON C-12

DATE _____ WORKSHEET

COMMERCIAL & STORAGE GARAGES

1. A parking garage is: _____
_____
_____
_____.

2. Each floor up to _____ above the floor is considered class_____ Division _____ unless mechanical ventilation provides a minimum of _____ air changes per hour.

3. Pits and depressions below floor level shall be considered Class ___ Division _____ locations. If _____ air changes per hour are exhausted at the floor level of the pit, it may be classified as a Class _____ Division _____.

4. Can a wire-guard drop cord with switch and receptacle be used in a commercial garage? _____ Answer is found in Article _____ _____.

5. Raceways embedded in a masonry wall or buried beneath a floor shall be considered to be _____ the hazardous area above the floor.

6. Conduit seal-offs (are-are not) _____ required in commercial garage areas, with in the horizontal and _____ boundaries of the defined hazardous areas.

7. List six (6) types of wiring methods which may be used above hazardous areas:

   a. _____ e. _____

   b. _____ f. _____

   c. _____

   d. _____

8. Receptacles in non-hazardous areas shall be of _____ type.

9. Battery _____ equipment shall not be located within the hazardous area.

10. Can electric vehicles be charged in a commercial storage garage? Yes/No _____ Give the code section _____.

11. Flexible codes shall have:

a. Approval for _____ usage
b. Adequate _____ for charging current
c. Connector rating of no less than _____ amperes.
d. Connectors will _____ readily at any position.

12. Is a molded composition switched lampholder with a grounded plug-in receptacle permitted in a commercial garage? _____ Give N.E. Code to support your answer. _____.

_____

NAME _____ LESSON C-13

DATE _____ WORKSHEET

AIRCRAFT HANGARS

1. The entire hangar floor up to a level _____ inches above the floor is considered to be Class _____, Division _____, area

2. The area 5'-0" above an aircraft wing is considered a Class _____, Division _____, area.

3. Any area within _____ feet of an aircraft is considered hazardous.

4. Fixed wiring in the non-hazardous area of a hangar shall be installed in _____, _____, Type _____ cable or Type _____ cable.

5. Seals shall be installed on _____ passing from hazardous areas.

6. Aircraft _____ shall not be charged while the aircraft is located in the hangar.

7. All metallic raceways and non-current-carrying parts of fixed equipment or portable equipment regardless of voltage shall be _____.

8. Service equipment not equipped for Class I, Division 2 locations shall not operate within hazardous locations and within _____ feet of aircraft.

9. What type of permanent warning sign shall be attached to mobile aircraft energizers and service equipment?

10. Aircraft energizers should have automatic controls to _____ the ground power unit electrically in case excessive _____ is generated.

11. Aircraft energizer flexible cords shall include a _____ conductor, and be approved for _____ usage.

12. Does portable mobile service equipment operated near aircraft which operates at a low voltage have to be grounded? _____ Give N.E. Code section for your answer. _____

NAME _____ LESSON C-14

DATE _____ WORKSHEET

GASOLINE DISPENSING AND SERVICE STATIONS

1. What locations shall be included in the classifications?

   _____
   _____
   _____

2. List the three areas of a gasoline dispenser which are classified as Class I, Division 1, locations:

   (a) _____
   (b) _____
   (c) _____

3. Any area located within 20 feet of the gasoline dispenser area shall be classified Class _____, Division _____.

4. What classification of hazardous area extends to 18 inches above drive?

   _____

5. What are the classification and limits around the tank fill pipe?

   _____
   _____

6. Electrical wiring and equipment below grade around the dispenser shall be classified as Class _____, Division _____.

7. List three conditions and classifications for tank vent pipes:

   (a) _____
   (b) _____
   (c) _____

8. Circuit breakers shall be capable of disconnecting all _____ conductors including the _____ simultaneously on circuits to dispensers.

9. Seals shall be installed in all conduits entering or leaving _____ pump or other enclosures located in Class _____, Division _____ or _____ when connecting conduit originates in a _____ - _____ location.

10. The first fitting in a dispenser after the conduit emerges from the concrete slab shall be a _____.

11. What electrical equipment must be grounded under this article?

(a) _____
(b) _____
(c) _____

12. Does all underground wiring have to be in rigid metal conduit? _____ Give Code section for your answer. _____

13. What other types of wiring are permitted?

(a) _____
(b) _____
_____

NAME _____ LESSON C-15

DATE _____ WORKSHEET

BULK-STORAGE PLANTS

1. List locations included under this Article:

   (a) _____
   (b) _____

2. In ventilated indoor areas containing a gasoline pump, the classification shall be Class _____, Division ____, for _____ feet horizontally and _____ feet vertically above the floor.

3. The immediate area within _____ feet horizontally and ____ vertically above the pump shall be classified as Class ____, Division _____.

4. List restrictions and classification for an unventilated area containing a gasoline pump.

   (a) _____
   (b) _____
   (c) _____
   _____

5. List restrictions and classifications for an outdoor pump installation.

   (a) _____
   (b) _____
   (c) _____
   _____

6. Office buildings outside the 25-feet radius of the storage tank have a _____ - _____ classification.

7. All electrical equipment within the hazardous area shall conform to Article _____.

8. Underground plastic conduit or duct may be installed in a hazardous area if buried _____ feet or more below grade.

9. Where shall seals be installed? NEC SECTIONS: (a)_____
   (b) _____ (c) _____

10. What type of grounding is required under this Article?

    (a) _____
    (b) _____

11. Buried raceways under defined hazardous areas shall be considered to be _____ the hazardous area.

NAME _____ LESSON C-16

DATE _____ WORKSHEET

FINISHING PROCESSES

1. What are the three main methods of applying finishes?

   a. _____

   b. _____

   c. _____

2. What are the hazardous substances involved in applying finishes?

   a. _____ d. _____

   b. _____ _____ e. _____

   c. _____ f. _____

3. The hazardous classification of Class _____ Division _____, covers areas within _____ feet horizontally and _____ feet vertically of paint spray booths.

4. The hazardous classification of Class _____ Division _____, covers areas within _____ feet horizontally of dip tank and their drain boards.

5. The hazardous classification of Class _____ Division _____, covers the area beyond the limits of Class I, Division I, around paint spray booths and dip tanks.

6. What two requirements must be met for an area utilizing drying, curing or fusion apparatus to be classified as non-hazardous?

   a. _____

   b. _____
   _____

7. Is a lighting fixture approved for Class I, Division I, locations acceptable within the 20 ft. area of a spray booth? Yes/No _____ Give the N.E. Code section for your answer _____.

8. Explain in your own words the meaning of Section 516-3 (c) of the N.E. Code. _____
   _____

9. Give the five conditions which must be met to put a lighting fixture behind a panel of glass or other translucent material.

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

10. Electrostatic spraying equipment generally consists of the following components:

    a. _____

    b. _____

    c. _____

    d. _____

    e. _____

    f. _____

    g. _____

11. What four conditions will shut down an electrostatic spraying operation to prevent danger to the operator or a fire from starting?

    a. _____

    b. _____

    c. _____

    d. _____

12. What determines the hazardous rating of a powder coating operation?

    _____

    _____

13. List the two methods of applying coating powders.

a. _____

b. _____

CONSERVE FUEL PARTS MACHINES
C

NAME _____ LESSON C-17

DATE _____ WORKSHEET

HEALTH CARE FACILITIES

1. Article 517 in the N.E. Code contains 10 parts. List them and what they cover.

   a. _____ g. _____

   b. _____ h. _____

   c. _____ i. _____

   d. _____ j. _____

   e. _____

   f. _____

2. In a health care facility, what are the two main divisions of the emergency system?

   a. _____

   b. _____

3. What are the emergency system branches of a nursing home or residential custodial care facility?

   a. _____ b. _____

4. Feeders and branches of the above emergency systems shall be _____ from all other wiring systems.

5. All branches of the emergency system shall be restored to oepration within _____ seconds of a power interruption.

6. In patient care areas, what are the minimum requirements for an equipment grounding conductor.

   a. Size _____
   b. Material _____
   c. Construction _____
   d. Installation _____
   e. Bonding _____

7. What hazardous classification is given to areas used for storing flammable anesthetics or volatile flammable disinfecting agents?

_____

8. The entire anesthetics area up to _____ feet above the floor is classified as Class _____, Division _____, location.

9. Raceways in masonry walls are considered to be in a _____ area.

10. Conduits in block walls in an anesthetics area are in a _____ area.

11. Boxes in a masonry wall in an anesthetics area are in a _____ area.

12. MI cables may be installed in _____ areas.

13. List three types of wiring permitted in a hazardous area.

a. _____ c. _____

b. _____ d. _____

e. _____

14. Seals shall be installed in _____ passing from anesthetics area.

15. In anesthetics area, each circuit shall have a switch to disconnect each _____ conductor.

16. Each circuit shall be supplied from an _____ distribution system.

17. List three methods used for circuit isolation:

a. _____ c. _____

b. _____

18. Secondary voltage of an isolation transformer shall not exceed _____ volts.

19. Primary voltage to isolation transformer shall not exceed _____ volts.

20. Overcurrent _____ shall be installed in secondary neutral of isolation transformer.

21. Current through the ground indicator shall not exceed _____ _____-amperes.

22. Grounded branch circuits and ungrounded branch circuits shall be installed in _____ raceways in anesthetics area.

23. Fixed lighting fixtures in anesthetic area shall be mounted at least _____ feet above floor.

24. Switches for grounded circuits shall be located _____ of anesthetics area.

25. Electrical apparatus used in the hazardous area shall operate at a maximum of ____ volts.

26. Low-voltage supply from a common source for electrical apparatus in hazardous area shall be located in _____ locations.

27. Motors used in hazardous area shall be approved for Class _____ locations.

28. Overcurrent devices for low voltage equipment shall be installed in _____ areas.

29. General care areas shall have a minimum of _____ single or _____ duplex receptacles for each patient bed location.

30. Critical care areas shall have a minimum of _____ single or _____ duplex receptacles for each patient bed location.

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Motor Control Trouble — Remedy Table

The following table lists troubles encountered with motor control, their causes and remedies. This table is of a general nature and covers only the main causes of trouble.

Misapplication of a device can be a cause of serious trouble, however rather than list this cause repeatedly it should be noted here that **misapplication is a major cause of motor control trouble and should always be questioned when a device is not functioning properly.**

Actual physical damage or broken parts can usually be found quickly and replaced. Damage due to water or flood conditions require special treatment. See page 3 for recommendations for renovating water soaked motor control.

TROUBLE	CAUSE	REMEDY
	Magnetic Contactors and Starters	
CONTACTS		
Contact Chatter	1. Broken shading coil.	1. Replace.
	2. Poor contact in control circuit.	2. Improve contact or use holding circuit interlock (3 wire control).
	3. Low voltage.	3. Correct voltage condition. Check momentary voltage dip during starting.
Welding or Freezing	1. Abnormal inrush of current.	1. Use larger contactor or check for grounds, shorts or excessive motor load current.
	2. Rapid jogging.	2. Install larger device rated for jogging service or caution operator.
	3. Insufficient tip pressure.	3. Replace contact springs; check contact carrier for deformation or damage.
	4. Low voltage preventing magnet from sealing.	4. Correct voltage condition. Check momentary voltage dip during starting.
	5. Foreign matter preventing contacts from closing.	5. Clean contacts with carbon tetrachloride, contactors, starters, and control accessories used with very small current or low voltage should be cleaned with carbon tetrachloride and then with acetone to remove the carbon tetrachloride residue.
	6. Short circuit.	6. Remove short fault and check to be sure fuse or breaker size is correct.
Short Tip Life or Overheating of Tips	1. Filing or dressing.	1. Do not file silver tips. Rough spots or discoloration will not harm tips or impair their efficiency.
	2. Interrupting excessively high currents.	2. Install larger device or check for grounds, shorts or excessive motor currents.
	3. Excessive jogging	3. Install larger device rated for jogging or caution operator.
	4. Weak tip pressure.	4. Replace contact springs; check contact carrier for deformation or damage.
	5. Dirt or foreign matter on contact surface.	5. Clean contacts with carbon tetrachloride.
	6. Short circuits.	6. Remove short fault and check to be sure fuse or breaker size is correct.
	7. Loose connection.	7. Clean and tighten.
	8. Sustained overload.	8. Install larger device or check for excessive motor load current.
COILS		
Open Circuit	1. Mechanical damage.	1. Handle and store coils carefully.
Roasted Coil	1. Over voltage or high ambient temperature.	1. Check application and circuit.
	2. Incorrect coil.	2. Check rating and if incorrect, replace with proper coil.
	3. Shorted turns caused by mechanical damage or corrosion.	3. Replace coil.
	4. Under voltage, failure of magnet to seal in.	4. Correct system voltage.
	5. Dirt or rust on pole faces increasing air gap.	5. Clean pole faces.

TROUBLE	CAUSE	REMEDY
	Magnetic Contactors and Starters	
OVERLOAD RELAYS		
Tripping	1. Sustained overload.	1. Check for grounds, shorts or excessive motor currents.
	2. Loose connection on load wires.	2. Clean and tighten.
	3. Incorrect heater.	3. Relay should be replaced with correct size heater unit.
MAGNETIC & MECHANICAL PARTS		
Noisy Magnet	1. Broken shading coil.	1. Replace shading coil.
	2. Magnet faces not mating.	2. Replace magnet assembly or realign.
	3. Dirt or rust on magnet faces.	3. Clean and realign.
	4. Low voltage.	4. Check system voltage and voltage dips during starting.
Failure to Pick-up and Seal	1. Low voltage.	1. Check system voltage and voltage dips during starting.
	2. Coil open or shorted.	2. Replace.
	3. Wrong coil.	3. Check coil number.
	4. Mechanical obstruction.	4. With power off, check for free movement of contact and armature assembly.
Failure to Drop-Out	1. Gummy substance on pole faces.	1. Clean with carbon tetrachloride.
	2. Voltage not removed.	2. Check coil circuit.
	3. Worn or rusted parts causing binding.	3. Replace parts.
	4. Residual magnetism due to lack of air gap in magnet path.	4. Replace worn magnet parts.
PNEUMATIC TIMERS		
Erratic Timing	1. Foreign matter in valve.	1. Replace timing head complete or return timer to factory for repair and adjustment.
Contacts Do Not Operate	1. Maladjustment of actuating screw.	1. Adjust as per instruction in service bulletin.
	2. Worn or broken parts in snap switch.	2. Replace snap switch.
LIMIT SWITCHES		
Broken Parts	1. Overtravel of actuator.	1. Use resilient actuator or operate within tolerances of the device.
MANUAL STARTERS		
Failure to Reset	1. Latching mechanism worn or broken.	1. Replace part.
COMPENSATORS (MANUAL)		
Welding of Contacts on Starting Side	1. Inching, jogging and operating handle slowly.	1. Excessive inching and jogging not recommended (caution operator) move handle swiftly and surely to start position.
Welding of Contacts Running Side	1. Moving handle slowly to run position.	1. Move handle swiftly and surely to run position as motor approaches full speed.
	2. Lack of sufficient spring pressure.	2. Replace contacts and contact springs.
Damaged or Burned Transformer	1. Repeated inching and jogging.	1. Excessive inching and jogging not recommended (caution operator).
	2. Holding handle in start position for long periods.	2. Hold handle in start position only until motor approaches full speed.

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Water-Soaked Motor Control

GENERAL RECOMMENDATIONS

1. **CLEANING** — All equipment should be hosed down and scrubbed with a stiff brush. Water pressure should be limited to 25 pounds per square inch maximum on insulating parts. Water temperature should not exceed 90 degrees C., 194 degrees F. maximum. Carbon tetrachloride or any approved solvent should be used for a final cleaning of insulating surfaces, contact tips and magnet pole faces. Contact tips should also be cleaned with acetone to remove the film left by carbon tetrachloride. Steam cleaning should not be used except on cabinets and enclosures from which the interiors have been removed.

2. **DRYING** — Drying in the sun or in a warm, dry room will take about 2 to 4 days. If heat is used for drying, it should be limited to about 212 degrees F., preferably starting at about 150 degrees or lower and gradually building up to 212 degrees F. Plaster drying equipment, electric heaters, or baking ovens may be used. Approximately 24 hours drying by this method should generally be sufficient. For equipment operating at voltages above 250, greater caution in drying and cleaning should be taken, because of the greater susceptibility to insulation breakdown.

3. **LUBRICATION** — All mechanical joints, sliders, bearings, and moving parts should be cleaned and lubricated with any good lubricating oil. Exception: NO OIL SHOULD BE APPLIED TO CONTACT SURFACES OR MAGNET POLE FACES.

4. **FINAL CHECK** — Test insulation resistance with megger or ohmmeter. A 500 volt or 1000 volt megger is recommended; higher voltages are not suitable for testing controls rated at 600 volts. One megohm is recommended as minimum resistance but equipment may operate satisfactorily with less. In operation, normal drying will cause this resistance value to increase. Restore power to one device at a time, watching for evidence of leakage, spitting, or smoking. For all equipment passing up to this point, load may then be restored, watching for spitting or smoking at contacts. Check to be sure that no open circuit conditions exist

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SPECIFIC RECOMMENDATIONS

1. **COILS AND TRANSFORMERS** — Wash with clean hot water and dry by any of methods listed above, or by applying a low voltage (about 10% of rated voltage) to the coil for 2 or 3 hours. Magnet armature should be in open position or coil should be removed from magnet. For drying D. C. coils by this method, a resistor in parallel with the coil is recommended to provide a discharge path for the kick voltage induced when the circuit is opened. Special care should be taken to dry out D. C. coils, since in operation, the inductive voltage may be several times normal voltage. Check with the megger for insulation resistance (one megohm).

2. **MAGNETS** — Wash, clean, and dry with cloth or air hose. Lubricate bearings, pins, etc. Clean magnet pole faces with carbon tetrachloride to remove oil film and surface dirt which might cause the armature to stick.

3. **CONTACT SURFACES** — Clean tips with carbon tetrachloride, then with acetone to remove the carbon tetrachloride film. Filing the tips is not recommended, but may be used if the surface is very difficult to clean. Do not use sandpaper or emery-cloth which would deposit grit on the tips. Small contacts can be "filed" by rubbing Kraft paper over the surface. Particular care should be taken with small contacts such as electrical interlocks, overload relays, and push buttons.

4. **INSULATING PARTS** — All surfaces of contact blocks arc chamber covers, y[illegible]rs, overload relay blocks, etc. should be cleaned with [illegible]on tetrachloride, particularly between poles, and dr[illegible]efully. Surface drying is generally sufficient for glaz[illegible]orcelain, melamine, and non-absorbent plastics. Unglazed porcelain, bakelite, and Rostone absorb water and should be baked to dry thoroughly. (Rostone is the cold molded material used for contact blocks on Size 1, 2, and 3 starters.) Check with megger from pole to pole and from each pole to ground, for one megohm minimum insulation resistance.

5. **THERMAL OVERLOAD RELAYS** — Melting alloy type relays should be partially dis[illegible]bled to permit cleaning contacts and moving parts. Lubricate to be sure parts can move freely. Clean heater surfaces to permit normal heat radiation. Bimetallic type overloads should not be taken apart, because of their intricate assembly. For emergency service, they can be used if they check satisfactorily, mechanically and electrically. To check mechanically, remove heater unit and press downward on lower end of bimetal strip with a screwdriver; this should trip the relay and open control circuit contacts. Ultimately, bimetal overload relays should be replaced.

6. **SNAP SWITCHES** — (Class 9007, Type A0) snap switches should generally be replaced as soon as possible. For temporary use, shake out any water trapped inside, blow out with an air hose, and bake to dry. Check circuit continuity. Dirt inside the case may prevent contacts from closing properly and cause excessive wear on the toggle mechanism. It is generally impractical to attempt opening the case to clean it out.

7. **PNEUMATIC TIMERS** — Timer heads should not be taken apart. It is recommended that the timer be replaced or returned to the factory for repair. For temporary use, dry timer thoroughly and treat coil, magnet, and snap switch as recommended. Check timing operation. Timer should be suitable for limited use, but will probably not be very accurate, due to dirt in the valves.

NAME _____ LESSON C-18

DATE _____ WORKSHEET

FUNDAMENTALS OF MOTOR CONTROL

A. Match Column B with Column A:

Column A		Column B
_____	1. A requirement of service at constant load for an unlimited period.	a. Automatic b. Motor control c. Manual controller d. Semi-automatic e. Continuous duty f. Compensators g. Drum switch h. Full-voltage
_____	2. Basic functions are performed by hand.	
_____	3. These items are used on large horsepower motors.	
_____	4. The type of control that is used when we have a magnetic starter on a push button "Stop-Start" switch controlling motor.	
_____	5. Controls eliminates the necessity of a manual control.	
_____	6. Means the governing or regulating the functions of a motor or machine.	
_____	7. What is the most popular manual controller.	

B. Answer the following:

1. What is the purpose of a master switch?

2. What is the purpose of overload protection in a motor circuit?

3. Why are relays used?

4. How does a phase failure device operate?

NAME _____ LESSON C-19

DATE _____ WORKSHEET

CONTROL OF MOTOR STARTING

1. List two "methods of stopping" a motor.
   a. _____
   b. _____

2. What type of relay is connected across the line during starting of a reduced-voltage starter to prevent damaging the motor windings or auto transformer? _____

   _____

3. How is phase-failure protection provided? _____

   _____

4. When does single phase occur in a three-phase motor? _____

   _____

5. What type pilot devices provide an under-voltage protection?

   _____

6. List four general types of speed control.
   a. _____
   b. _____
   c. _____
   d. _____

7. Match Column B with Column A:

Column A		Column B
_____	1. What is provided by connecting a heater element in series with the motor leads?	a. Manual control b. Overload relay c. Overload protection
_____	2. What is sensitive to operators reaction only?	
_____	3. It does not provide short-circuit protection.	

8. List three means of short-circuit protection.

   a. _____ c. _____

   b. _____

9. List the two elements of a dual-element fuse. Give the purpose of each.

   a. _____

   b. _____

10. Interlock in a starter may be accomplished by _____ or _____ connection.

11. Why use reduced voltage starting? _____

    _____

12. What is the most popular starter used? _____

    _____

NAME _____ LESSON C-20

DATE _____ WORKSHEET

CONTROL COMPONENTS

1. List the six main components of an automatic synchronous motor starter:
   a. _____ d. _____
   b. _____ e. _____
   c. _____ f. _____

2. The most common _____ motor starts like a squirrel-cage motor.

3. The most critical component in a synchronous motor starter is the _____ - _____ relay.

4. List seven main components of a semi-automatic synchronous motor starter:
   a. _____ e. _____
   b. _____ f. _____
   c. _____ g. _____
   d. _____

5. The most common secondary control component for wound-rotor motor starters is the _____ _____.

6. List the five main components of a wound-rotor motor starter:
   a. _____ d. _____
   b. _____ e. _____
   c. _____

7. Liquid _____ type secondary controller provides the smoothest speed regulation for a wound-rotor motor.

8. List two methods of manually reversing three-phase squirrel-cage motors:
   a. _____
   b. _____

9. List two methods of automatically reversing single-phase fractional horsepower motors:
   a. _____ b. _____

10. In lieu of a reversing starter, _____ across-the-line starters, properly connected, may be used.

11. Starters or _____ are a common component to all motors for disconnecting the motor.

12. An isolating switch is rated in _____ and _____.

13. A switch that is horsepower rated is the _____ - _____ disconnect and will interrupt motor current under normal _____.

14. When the above switch is used for motor-circuit protection, it must be _____.

15. A circuit breaker may perform start and stop functions, and _____ and _____ _____ protection.

16. A circuit breaker may be used as a motor-circuit _____.

17. Contactors do not provide _____ _____.

18. List two general types of contactors:

    a. _____

    b. _____

19. Contactor is a _____ _____ switch.

20. A relay is a _____ amplifier.

21. A relay _____ require a low current for functioning and may be used to _____ circuits of large currents.

22. A _____ relay is the most common type.

23. List five types of relays:

    a. _____ d. _____

    b. _____ e. _____

    c. _____

24. Components which use signal relays are called _____ _____.

25. Current relay operates on _____ to current changes.

26. Relays which are used on very low current circuits are called _____ - _____.

27. List two types of current relays:

    a. _____ b. _____

28. An overload relay provides overload and _____ - _____ protection in motor circuits.

29. List three types of overload relays:

    a. _____

    b. _____

    c. _____

30. Thermal relays trip on heat and are called _____ _____ relays.

31. Magnetic overload relays sense motor _____.

32. Overload relays must be reset after each _____.

33. What is the difference between a "motor-starter" and "motor controller"? _____
    _____
    _____

34. NEMA Type _____ enclosures are for general purpose use.

35. NEMA Type 3 enclosures are _____ - _____.

36. A _____ motor starter depends upon the operator to close the line contacts by pushing a button which is physically linked to the contacts.

37. A _____ motor starter closes the line contacts magnetically.

38. The manual starter lacks _____ of control.

39. List three classes of manual starters:

    a. _____

    b. _____

    c. _____

40. The _____ starter provides unlimited flexibility of control.

41. List the two classifications of the magnetic starter:

    a. _____ b. _____

42. Full-_____ starters are the most widely used.

43. Reduced-voltage starters are used to limit the _____ _____ _____ during the starting cycle.

44. Conpensators are _____ reduced-voltage starters.

45. Closed-_____ start occurs when there is no interruption of current from reduced-voltage to full-voltage operation.

46. Auto-_____ reduced voltage starter is an open-transition starter.

47. Magnetic starters for multispeed motors must have a _____ for each speed.

48. List the three types of multispeed control:

    a. _____

    b. _____

    c. _____

49. The combination _____ includes a switch or circuit breaker and a motor starter in the same enclosure.

NAME _____ LESSON C-21

DATE _____ WORKSHEET

PILOT DEVICES

1. Motor-control circuit components may be classified as _____ _____ devices or _____ _____ devices.

2. Pilot control devices _____ or _____ primary control devices.

3. A magnetic starter is a _____ _____ device.

4. List four types of pilot devices:

   a. _____ c. _____

   b. _____ d. _____

5. List two primary control devices for a motor:

   a. _____ b. _____

6. Overload _____ are pilot devices.

7. Pilot _____ are sensing devices.

8. Float _____ operates on the level of liquids.

9. List two types of float switches:

   a. _____ b. _____

10. List three classes of pressure switches:

    a. _____

    b. _____

    c. _____

11. List two classifications of limit switches:

    a. _____ b. _____

12. Flow _____ sense the flow of liquid, air or gas through a pipe.

13. List three types of thermostats:

    a. _____

    b. _____

    c. _____

14. Push - _____ _____ is most commonly used pilot devices in motor-control circuits.

15. List two types of push-button stations:

    a. _____ b. _____

16. Maintained-contact type push button operates motor-control by _____ _____.

17. Momentary contact type push button operates motor-control _____.

18. Time clock _____ open and close contacts at pre-determined times.

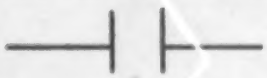
19. Quality should never be _____ in pilot devices.

NAME _____ LESSON C-22

DATE _____ WORKSHEET

CONTROL-CIRCUIT DIAGRAMS

1. Describe the function of the following symbols:

a.  _____

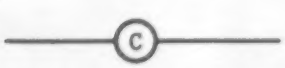
b. _____

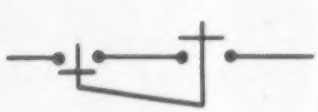
c. _____

d. _____

e. _____

f. _____

g.  _____

h.  _____

i. _____

2. The _____ _____ is the written language of control circuits.

3. List three general types of control diagrams:

   a. _____

   b. _____

   c. _____

4. A _____ diagram is best suited drawing for making initial connections of a _____ _____.

5. A _____ _____ is easiest drawing to understand.

6. A one- _____ _____ is compact and eliminates some confusion when many wires are indicated.

7. Wiring diagram is a drawing of the _____.

8. What is the chief advantage of the wiring diagram? _____

   _____

9. Most circuit diagrams are first developed by drawing a _____.

10. A wiring diagram is a representation of the _____ in its _____ electrical sequence.

11. A _____ _____ is read from left to right.

12. Symbols are used to identify _____ _____ and _____ in a schematic diagram.

13. How is a schematic diagram developed from a wiring diagram?

    _____

    _____

    _____

    _____

14. "Start" push buttons or components are connected in _____.

15. "Stop" push buttons or components are connected in _____.

16. The duty of device will determine whether it will be connected in _____ or _____ in a circuit.

17. Draw a one-line diagram showing symbols for a start-stop button station and starter for a motor.

NAME _____ LESSON C-23

DATE _____ _____ WORKSHEET

DEVELOPMENT OF CONTROL CIRCUITS

1. How are control circuits developed? _____

   _____

2. List two basic types of control circuits:

   a. _____

   b. _____

3. Push buttons which are used on three-wire control circuits are called _____ - _____.

4. Push buttons which are used on two-wire control circuits are called _____ - _____.

5. Momentary-contacts control circuits provide _____ - _____ _____.

6. Draw a schematic control diagram 1/6 HP unit heater motor having a manual "Start-Stop" toggle switch, an "On-Off" thermostat and "On-Off" aquastat which requires the water to be a pre-determined temperature before the motor can operate.

7. Draw a schematic control diagram of two exhaust fans with magnetic starters, actuated by a remote "Start-Stop" push button, time switch or thermostat if the temperature in the room exceeds a pre-determined temperature.

MATERIAL TAKE-OFF

1. From the house plan, list the material you would need to rough the job in, trim it out, and leave it ready for occupancy. The owner will supply the fixtures. Material should be listed for the following general uses:

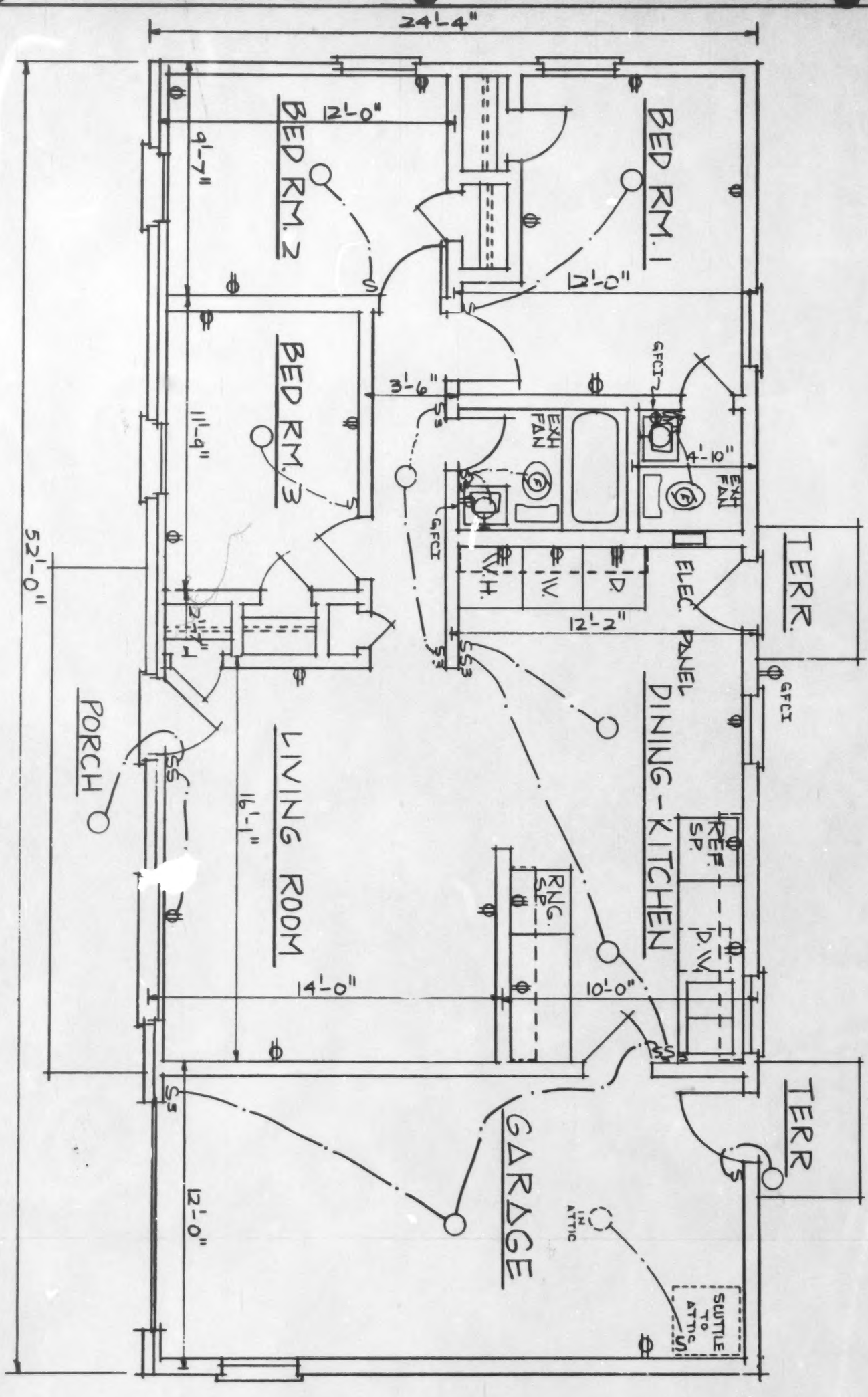
    a. Lighting and receptacle outlets
    b. Major appliance outlets
    c. Heating system (one system only)
    d. Air conditioning system (one method only)
    e. Panel and service

2. Types of material to be listed should include:

    a. Boxes
        (1) Outlet - fixture stud
        (2) Switch
        (3) Receptacle
    b. Cable - size and number of conductors
    c. Devices and plates
    d. Fastening materials - screws, anchors, straps, staples
    e. Panel - size main bus, number and size of branches
    f. Service - cable, grounding conductor, ground rod or pipe, entrance cap, meter box-pick up from utility

NOTE: These lists were circuited out and compiled by a contractor's estimator who specializes in single and multi-family dwellings. A student error of 10% would be considered reasonable due to a lack of experience.

No one student should need more than 5 of the eight material list categories to complete one method of total electric comfort conditioning the residence (i.e. only one method of heating and one method of cooling plus lighting and receptacle outlets, major appliance circuits, and the panel, service, and grounding).



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GUILFORD TECHNICAL INSTITUTE, JAMESTOWN N.C. ARCHITECTURAL TECHNOLOGY DEPARTMENT	FLOOR PLAN	STUDENT: GARY ROBBINS STUDENT NO. 6248 326 PINEVIEW ST ASHEBORO, N. C. SHEET NO. 1 OF 1.

ESTIMATING

An estimate is an accurate and factual appraisal of the probable cost of doing a job.

The cost of doing a job consists of a number of items; a few major ones are:

a. Material
b. Labor
c. Taxes and insurance
d. Bonds
e. Tools and equipment
f. Job and office overhead
g. Profit

All of the above items have some built-in variations, but generally it takes a set amount of material to accomplish a given electrical job.

Once an accurate material list for a job is made, an estimate of the man-hours needed to install this work must be made. The tools and equipment needed to do the job must be figured into the estimate, along with taxes, insurance, bonds, and the non-production labor (office workers-payroll, billing, estimating, warehousemen, engineers, accounting, secretaries, salesmen, etc. who keep the wheels turning). To this list of figures is added profit.

Notice that an estimate is a group of variables stacked one upon another yet all based on the quantity of material necessary to make the electrical installation.

Your job as an electrician is to be able to take the material required to do the job and install it within the time allotted. You must be able to see the job from the plans the same way the engineer designed the job and as the estimator saw it when he took the job off the plans.

To install the work, you must know the many component parts which make up the complete installation--where they fit into the work, how they are fastened in place, and how to interconnect them electrically. Without all of this knowledge, the job cannot be done to fit the plans, the budget, the N. E. Code requirements, and the user's needs.

NAME _____ LESSON C-25

DATE _____ WORKSHEET

ESTIMATING

1. What are the seven major items in compiling a job estimate?

   a. _____ e. _____

   b. _____ f. _____

   c. _____ g. _____

   d. _____

2. Which of the above items is the key to an accurate estimate?

   _____

3. Which of the above items are subject to the efficiency of the electrician?

   a. _____ c. _____

   b. _____

4. Which of the above items is a known operating expense that most owners insist on having the contractor supply? _____

5. Which of the above items is a known operating expense that the contractor must have to keep a smooth-running company?

   _____

6. What are the major items covered by taxes and insurance?

   a. _____ d. _____

   b. _____ e. _____

   c. _____

7. Of all the items which make up the bid price of a job, which one is beyond the contractor's direct control? _____

8. On a bid job which must be installed according to strict plans and specifications, why are there differences in bid prices? List three.

a. _____

_____

b. _____

_____

c. _____

_____